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THE ELECTRICAL REVIEW

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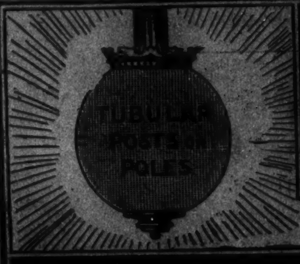

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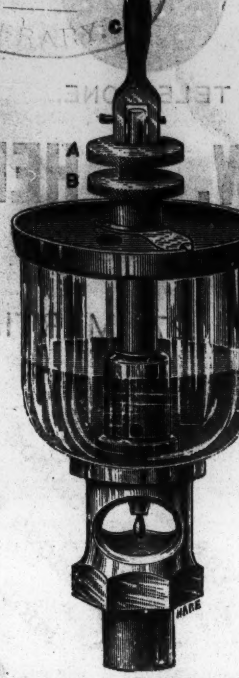

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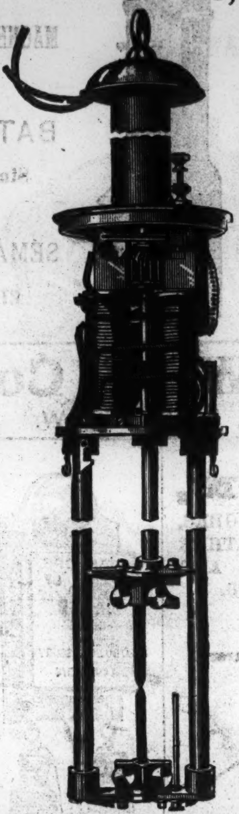

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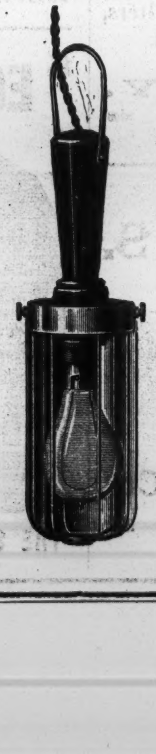

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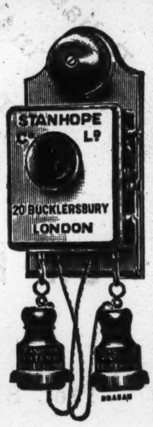

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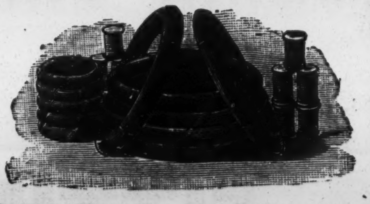

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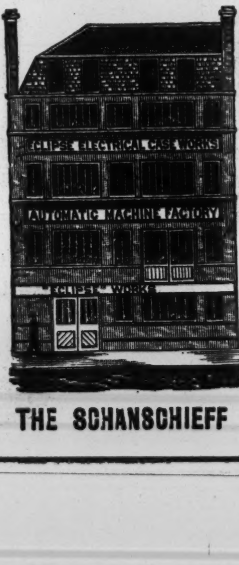

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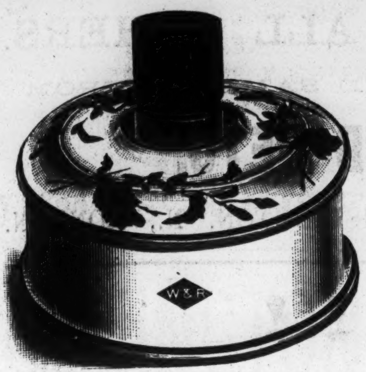

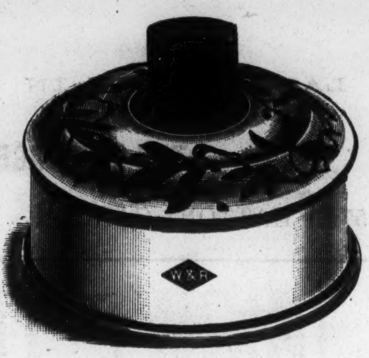

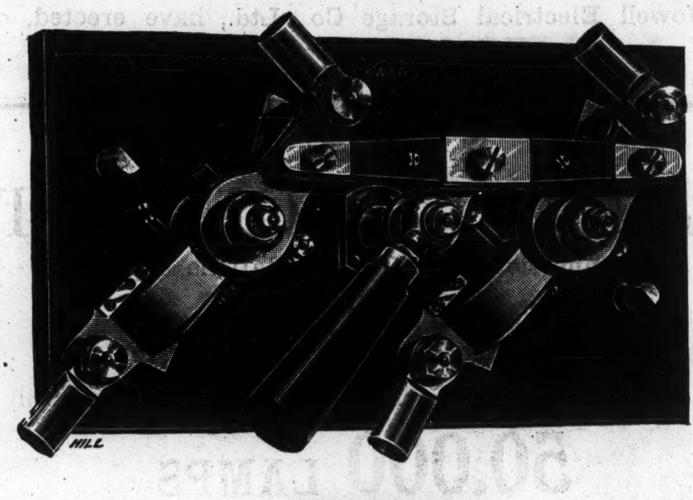

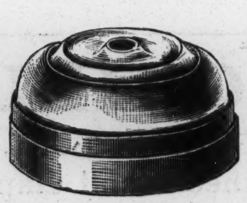

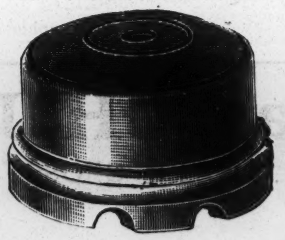

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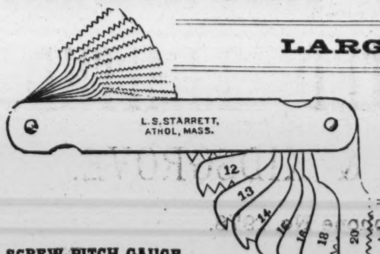

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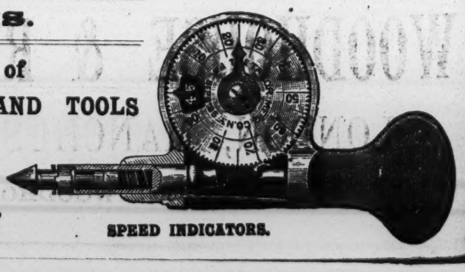

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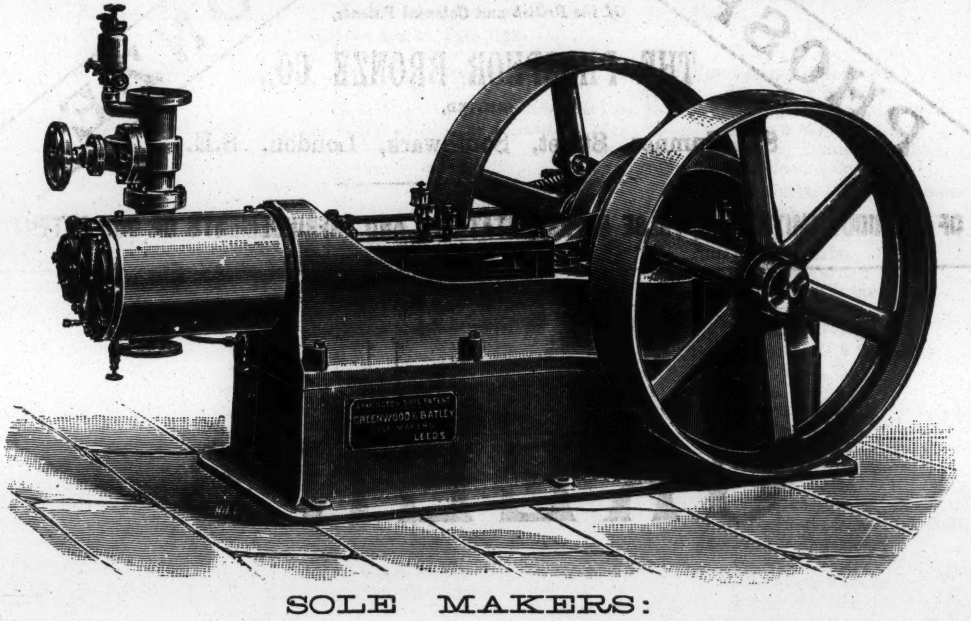

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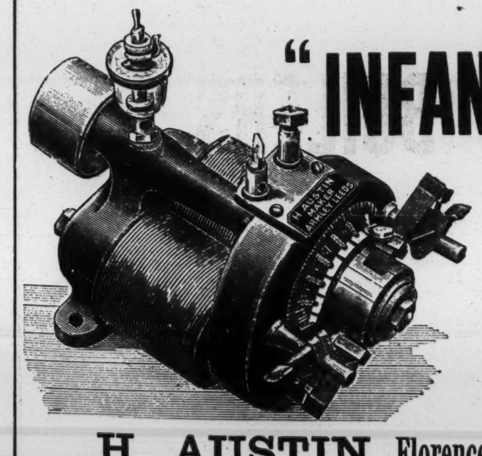

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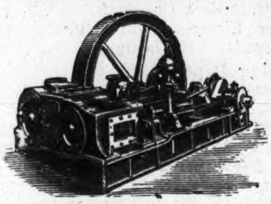

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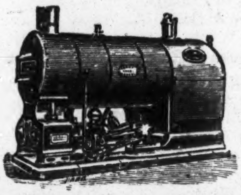

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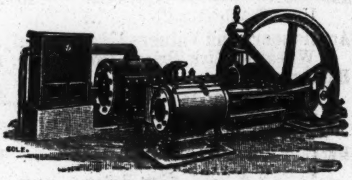

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VOL. XXVII. OCTOBER 10, 1890. No. 672

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THE LABOUR QUESTION.

TRADES unionism, which has given us many varied and altogether unpleasant experiences, has seldom shown its true character so distinctly as during the last week, and it is somewhat humiliating, as Englishmen, to be obliged to confess that the qualities of the labouring man, as a unionist, most prominently brought into notice—that is to say, if he be rightly represented by his spokesmen—are those of a bully, a sneak, and a perverter of the truth. By this time there must be but very few persons sanguine enough to still place any faith in the word or bond of the British workman. This is not very pleasant talking, but it is impossible to come to any other conclusion after a consideration of the events of, let us say, the last twelve months. For the moment, indeed, difficulties seem to be tided over, but at any instant and, as it is now made public with almost brutal cynicism, without any preliminary warning, employers may find their works bare of men, their cargoes awaiting to be unloaded, their machinery standing idle, and their steamers detained for want of coal.

It would really seem hopeless to expect the arrival of the day when it will be brought home to the labouring man that if capital be prevented from obtaining labour in one locality it will surely succeed in meeting with it elsewhere, and that, just as certainly, if capital be debarred from an outlet in one direction, it cannot be idle, but must seek a course for its natural functions under other more favourable circumstances and conditions.

The difficulties with which trades unions are seeking to surround the free employment of labour and an untrammelled development of industry, can have but one result—the alienation of capital, and consequently of work; indeed, the present effects are serious enough, without borrowing any possibilities from the future. The docks and river strikes have already diverted an enormous amount of business from the Thames, and, with more particular reference to that trade organisation which has been trying to play a lone hand, large contracts have been recently made with firms in the Canary Islands for the supply of coal for a long period to certain important lines of steamers. This is a more serious matter than would at first appear, for although it is at present only a question of coaling ships, it is the first step towards the building up, at the expense of the labouring man in England, of alien enterprise and industry.

Amidst the labouring population there surely must be men of clear sight and sound judgment, and it seems strange that these cannot appreciate the fact that the cry of "capital *versus* labour" is nothing but a catchword, and beyond serving, for the want of a better, the purpose of a party-cry, is absolutely meaningless. Capital must, perforce, be brought into utilisation by means of labour, and if muscle cannot be depended upon to fulfil its engagements, one consequence, among others, overlooked to a great extent because the effects are not immediately appreciable, is that the incentive to perfecting labour-saving appliances receives increased stimulus.

No one could for a moment attempt to deny the misery existing among some of the working classes, and it is brought into the stronger relief from the squalor of their surroundings and the utter improvidence of their habits. The stern and immutable law of nature that the weakest must succumb in the struggle for existence is nowhere so painfully evident as in our teeming population, our overcrowded districts. The labouring classes can no more expect to be exempt from this law than any other order; the strongest, mentally or physically, must eventually push to the front. Any attempt to bolster up the weak and incapable can only result in the lowering of the general average, and this is precisely what will happen if the inefficient workman is to be paid the same as the capable. The survival of the fittest may sound a heartless axiom, but it indicates the only sound and healthy condition of society. The bringing of all labour to an equality in remuneration is an attempt to promote the welfare of the ignorant and thriftless at the expense of the competent and ambitious; it would eliminate competition, which is the life and soul of all progress, individual or national; and reduce mental and physical faculties to a dull dead level of mediocrity.

The subject is one we have repeatedly brought before our readers, and, unfortunately, the occasion is too frequently given to us of reverting to the ill-directed struggles of the working man to assert his independence, and to the attempts of party leaders to subvert the natural laws of supply and demand to illegitimate ends.

MORE ELMORE.

"IT looks as if Baron Grant is coming to the fore again. We understand that the Baron has had a good deal to do with bringing out some of the Elmore copper companies. City men used to say that he could draw up a prospectus better than any man in London."

The *Star* of Saturday last is responsible for the foregoing.

If any explanation were needed for again referring to the subject, it would suffice to say that the Baron is not likely to leave a fruitful field untilled.

> "Kings can titles give, but honours can't,
> Title without honour is a barren grant."

We are sorry that the Baron has taken electrical ventures under his wing. Mines were at one time his favourites. Through the "Emma" the public lost a considerable sum, though very important names were on the board. It was, we believe, the action of Rubery *v.* Grant which led to the fall of a Sampson, and journalists will not soon forget the circumstances which preceded the placing of "Printing House Square" at the head of the *Times* money article. Association with the Baron has hitherto boded ill.

So long as Elmore companies can be successfully floated, Elmore companies will be issued. We hold it to be the duty of those who can in any way throw light upon the subject not to spare any trouble in doing so. The bases of the issues are prospectuses, reports, and patents. We purpose examining these in their order, with a view to discover their salient features. To-day we deal with the prospectuses.

Following is a list of the companies already floated, with the amounts of capital issued, and the prices paid for their rights :—

Company.	Capital issued.	Purchase Price.	
		Cash.	Shares.
Elmore Co. (British) ...	£140,000	£53,400	£46,600
Elmore Wire	200,020	75,000	20
Premium	100,000	50,000	
Elmore Co. (Foreign and Colonial)	120,000	80,000	30,000
Elmore Co. (French) ...	200,000	83,500	66,500
Premium	33,375	33,375	
Elmore Co. (Austro-Hungarian)	200,000	50,000	50,000
Premium	37,500	37,500	
	£1,030,895	£462,775	£193,120
		£655,895	

It will be seen that of the capital issued more than half has been paid away for rights, and that the vendors have a preference for cash. It may be noted, too, that the vendors to the Wire Company were content with half the premiums. The vendors to the French and Austrian Companies took all the premiums.

The patentees, or original vendors, received in cash and shares from the British and Foreign and Colonial Companies £210,000.

The British Company paid £100,000, and received from the Wire Company, for a partial license, £125,020.

The Foreign and Colonial Company paid £110,000, and received from the French and Austro-Hungarian Companies £320,875.

The five companies have 29 directorships. Fifteen gentlemen fill these. Mr. William Elmore is a director of four companies. Four other gentlemen are directors of four; two of two.

Messrs. F. E. and A. S. Elmore are either joint works managers, or joint consulting metallurgical chemists, to all the companies, without exception.

One gentleman acts as secretary of all the companies, without exception.

The prospectuses are nearly all alike, as we pointed out last week. The compilers of the original must be credited with having fairly exhausted the subject, including the Bessemer comparison. One of those points which strike us, on a reperusal of the prospectuses, is the sudden way in which a series of conjectures or estimates becomes "the above plain statement of facts."

Tracing the estimates in the later prospectuses back to their source, we find that in the Wire Company's prospectus it is stated that the estimate of cost of manufacture has been prepared by Mr. William Elmore.

It therefore comes down to this, that the figures upon which the directors base their calculations are the figures of one of the original vendors; the managers of the works in which any practical work may have been done being also among the original vendors.

The question we are naturally inclined to ask the directors is, whether, in a matter of such importance, it is altogether wise to base so much on the estimates of those who might reasonably be expected to develop a sanguine temperament.

A Record.

"SINCE then electricity comes not from the sun as from a heated body, it comes from its home the bowels of the earth. When God first created everything beautiful in its time (Eccles. iii.) as well for man's needs as to reflect his own glory, He placed latent heat, electric fire, in the centre of the earth as its nucleus, to radiate from the centre to the circumference, and to thereby hatch and vivify and cause to grow everything to which He had imparted life." "When the collapse of the eggshell crust (of the earth) comes, it will not be from the atmosphere from above driving it into a vacuum from below, which could not exist, but the presence of the fires and electricities of the earth, chockfull of them, overcoming the resistance of the lighter electricity in the atmosphere above and its vacuums and universal cyclones." The above are not extracts from the works of Roger Bacon, or Paracelsus, but from a letter written by T. W. Christie, B.A. (Camb.), to the *Liverpool Courier* of Wednesday last, with the view of expounding to the readers of that journal, "where electricity comes from." In the same letter Mr. Christie propounds the theory that the sun is not hot, but shines and warms by reflected light and heat. We should not be surprised to hear that Mr. Christie believes that the earth is flat, or that the earth is the centre of the solar system. Considered as a sample of "newspaper science," Mr. T. W. Christie's letter has, we think, made a record.

Elmore Wire.

A WELL-KNOWN electrical expert who, if we mistake not, has taken a prominent part in testing Elmore copper wire, is stated to have said that under precisely similar mechanical conditions its conductivity is better by 2 per cent. than any other copper, electrically deposited or otherwise, with which he was acquainted. This slight difference is not likely to cause rival manufacturers much serious inconvenience, as we have previously pointed out a manner by which compensation may be made for any such small deficiency in conducting power. Moreover, we have yet to learn at what price this "extra high conductivity" wire can be put on the market.

National Telephone Company. A High-handed Policy.

A MR. ERSKINE MUIRHEAD, writing to a provincial newspaper, complains of a high-handed proceeding on the part of the National Telephone Company. It appears that Mr. Muirhead, at the request of the company, brought over to this country several telephones of the Ader and Berthon type; immediately afterwards Mr. Muirhead received a note from the company saying that the telephones in question were a direct infringement of their patents, and unless they were returned to France at once an action at law would result. If the facts are as stated, a more gross case can hardly be imagined; but we cannot but think that Mr. Muirhead has not fairly represented what has actually happened, for it would only be necessary to prove in Court that the company had invited Mr. Muirhead to bring over the instruments, for the action to be dismissed with costs. Mr. Muirhead also complains that, as a consequence of the dispute apparently, he was cut off from the Telephone Exchange, although he had signed the usual contract, under which he had the right to a further year's use of the privilege. The cause of all this is stated to be that the Ader-Berthon telephone is much superior to the existing apparatus, and that were it once tried by the public there would be a general demand all round for its adoption. Mr. Muirhead states that "as the patent will expire in a few days, he will be glad to fix a pair in the office of the provincial journal in question;" he does not state to what patent he refers, but inasmuch as the Edison patent, which has practically been held to cover the use of carbon, does not expire till July of next year, it is difficult to see what right he has to fix the telephones in question in a few days. At the commencement of his letter Mr. Muirhead states that the Ader and Berthon telephones are in daily use, speaking between towns over 600 miles apart, this, we presume, being brought forward as an argument for the superiority of the instrument; as a matter of fact, it ought to be pretty well known now that to speak over 600 miles is not such a very marvellous feat, as the question is not one of instruments but of a sufficiently large *copper* wire. The Blake instrument, as used by the telephone companies, is not a satisfactory apparatus, as it requires careful adjustment to make it work properly; there are plenty of microphonic transmitters of simple design which are more efficient and require no adjustment whatever, but to substitute these would involve very great expense.

The Elmore Copper Company.

THOUGH our remarks in another column bear on some of the points raised by "a shareholder," we think it may be well to deal with them here *seriatim.* We gave, as we think, good reasons for raising the question of justification for companies in some countries, even assuming the success of the process—say, in England—so we need not follow our correspondent into the regions of political economy. We are awaiting the proofs which our correspondent takes for granted in the next paragraph, and we are obliged to differ with him in his logic of criticism. "A shareholder" has reached the nutshell; we want to get at the kernel! We do not doubt that Elmore shareholders will consider our six columns might have been devoted to better purpose; at the same time, they will perhaps allow that we are the better judges on that point, for we attach no importance to the company's guarantees of their manufactures at present. Our correspondent should be aware that we do not condemn without enquiry. We are enquiring, and we have not condemned the invention, but we do condemn most strongly the promotion of sub-companies, and the payment of large sums for the invention in its present stage. "A shareholder's" second point may be left to the common sense which settles things "on evidence which cannot be fairly disputed." The statement that Mr. Clark was not referring to Elmore copper we take to mean, also, that he was not referring to copper "made in the same way as Elmore copper." If this be so it is of value, and we are much obliged to our correspondent for pointing it out. We shall bear it in mind in our further enquiries, but so far as our last week's article is concerned Mr. Clark's evidence may be removed from it entirely without modifying in any way the conclusions at which we arrived. We attach no importance whatever to the fact that Mr. Parker has become a shareholder. Without being quite sure that we understand the intent of his concluding paragraph, we imagine that "a shareholder" thinks that it will take considerable time and much puffing of Elmore copper to bring about the impending revolution. So do we! There is no necessity for "a shareholder" to write himself down a fool and say we called him so. We did not say that all Elmore shareholders were fools. We do not think they are. Something depends on the companies they are in, and we are not sure whether some of them may not deserve a different appellation, which we hold in reserve.

ON THE PROTECTION OF BUILDINGS FROM LIGHTNING.*

I MAY, perhaps, be permitted to state in a few words why I have chosen lightning for the subject of my paper. My reason is that considerable uncertainty is reputed to exist amongst architects, builders, engineers, and others, who are occasionally, although not professed electricians, called upon to erect lightning conductors, and particularly because I have had quite recently two cases illustrative of this suspected uncertainty brought forcibly to my notice, one of the two cases being one in which a number of persons narrowly escaped with their lives. It seemed to me, therefore, that lightning conductors offered a meet and appropriate subject for discussion by this Association.

The first case occurred in connection with this present exhibition. The electrical and lighting committee decided that both the old and new systems of protection should be illustrated practically, so the chimney of the boiler house was ordered to be protected by a stranded copper rope of the ordinary type, and the minarets of the main building by iron wire, according to a design kindly furnished by Dr. Oliver Lodge. The erection of the chimney proceeded with unexpected celerity, and when the committee went to specify the precautions they wished to have observed in earthing the conductor, they were informed that the conductor was up, earthed and finished. The builder assured them that it was "all right;" but, appreciating the ridiculous figure that would be cut by an electrical committee were a chimney under their special care struck and injured, it was resolved to do violence to the builder's feelings, and dig up his earth. It was found that the end of the conductor was only a few inches below the surface, and was loosely embedded in builder's *débris*. That was the first case, and was detected and remedied in time. The second was only revealed by an actual visitation of lightning.

Last month, during a severe thunderstorm, and while it was raining very heavily, the inmates of a gentleman's house were startled by a tremendous report. Simultaneously a great light was seen in various rooms by different people. The house is peculiarly situated, being erected on the slope of a rocky hill, about 600 feet above the base, and some 1,000 feet below the summit. It is fitted with the electric light, all the leads being within the building. A telephonic connection exists with the stables in the valley below, some 1,000 yards distant; it consists of two copper wires thickly insulated with gutta-percha, which are used as a metallic circuit. They are underground the whole way, being laid in a wooden box buried in a trench, except at one point, where they cross a stream in an iron pipe laid in its bed. Within the house and stables the wires are led to the instruments in wooden boxing.

When the flash occurred light was seen in almost every room of the house. A tailor employed in one of them asserts that light played about his thimble and scissors, and the cook is positive that a flame appeared around her kitchen grate. The housekeeper, who was seated in her room, says she heard a faint rustling sound in the direction of one of the electric lamps. She turned her head, and was immediately conscious of a blaze of light which seemed to dart from the lamp to the grate. The next thing she remembers was finding herself on the floor, unhurt, but greatly terrified. She picked herself up and, strange to relate, made her way to a mirror, but for some minutes was unable to distinguish her reflection in it. The lady of the house saw, or believes she saw, a ball of fire, of a deep red colour, in the dining room, but others present were aware only of a dazzling light of no defined shape, which appeared to some of them to play for an instant over the wall paper, which is embossed with metal. At the stables end a groom states that a ball of fire, this time of a white colour, about the size of a cricket ball, appeared in the middle of the room and instantly exploded with a report that stupified and deafened him, and the effects of which he felt in his ears for several days. The light from the exploded ball seemed to diffuse itself in all directions, but he was conscious of a more intense action in the neighbourhood of the telephone.

An examination showed that the safety fuses of the electric light system were melted. The hinged door of the box containing them, which was situated about 4 feet from the telephone on the same wall, was knocked off and thrown to a distance. It was much scorched inside. The telephone wires were fused in three different places, once in the iron pipe in the bed of the stream, once midway between the stream and the stables, and once a few yards on the house side of the stream. At the second place the wooden boxing was completely destroyed for about 6 inches; at the third its bottom only was knocked out. In the stables the boxing was blown off the wall, but the wires escaped injury, as did the telephones at both ends. Where fused the wires presented a sharpened or pointed appearance on the sections furthest from the house and a rounded shape on those nearest it. In the stables, not far from the telephone, some wires, apparently connected to the earth, extended partly up the wall. They are said to have been used in connection with an A B C telegraph instrument which was formerly installed there.

At the moment of the discharge—as nearly as can be ascertained—in the house, two bullocks grazing in the fields two or three miles off were struck dead. This is a most interesting fact, for it tends to substantiate what has often been asserted and sought to be established by evidence such as this, that lightning discharges frequently, if not invariably, are double; that at the moment a flash takes place from clouds to earth at one place another ascends from earth to clouds at another, a phenomenon to which the name of back or return stroke has been given. It is indeed necessary that something of the kind should happen if the comparison between lightning and Leyden jar phenomena and ordinary electricity generally is to hold good, for a circuit of some kind is a necessity. A vivid flash between clouds and earth at one point only argues a circuit completed elsewhere—that is to say, a good conducting region—an absence of a dielectric, between earth and clouds at another, just as the arc of an electric lamp signifies that there is a conducting circuit, invisible and lengthy perhaps, but still a circuit, connecting the carbons between which it plays. Such a condition may exist during rain to an extent sufficient to permit of invisible conduction over a considerable area, or an actual waterspout such as is common in the tropics may form the conducting link, leaving forcible rupture of the dielectric to take place at one point only. Absence of such a conducting region necessarily means two dielectrics, two ruptures, and two vivid and co-existent, although perhaps, and probably, widely separated flashes, stroke and back stroke. It is reasonable to suppose that lightning, at least sometimes, may be merely a neutralisation by means of the clouds of opposite tensions existing at different points of the earth's surface. As soon as the cloud is long enough to cover both points, and low enough for the tensions to overcome the resistance of the intervening air, the neutralisation takes place, the cloud simply acting the part of the discharging tongs between the knob and outer coating of a Leyden jar. Lightning usually occurs after a spell of sultry weather when there is an absence of moisture, and consequently of conductivity in the atmosphere. In damp weather the necessary neutralisation between different parts of the earth's surface takes place—according to this hypothesis—constantly and silently, for there is no longer a dielectric resistant enough to prevent it.

It proved that the house, an extensive one, is largely roofed with lead, and has several iron spires which, at their lower extremities, are in contact with the lead of the roof. The highest spire was found, after the storm, to be bulged and blackened at the junction of the iron with the lead. There are numerous metal rhones or drainpipes down the walls for carrying off the rain water. These are in contact with the lead-work of the roof above, but no provision is made for earthing them below—in fact, they are built into brick drains. When I add that there is no lightning conductor, and that the house is built on a thin layer of soil covering rock, it will be seen that—the existence of the telephone wires being taken into account—all the elements necessary for a first-class catastrophe were present. The absence of a conductor was accounted for by saying that when the house was built the architect stated that one was unnecessary. The proprietor was especially desirous of knowing how the electric light and telephone wires, which were wholly under cover and cased in, came to be struck. The explanation is not difficult. As is well understood, lightning is a discharge between two areas (these areas corresponding to the coatings of a Leyden jar) highly charged by electricity of the opposite signs. The clouds usually form one of these areas, and a high or prominent object on the earth the other. The principal path of a discharge is always that of the least resistance, or best conductivity, although partial discharges may likewise occur simultaneously by less perfect routes, and the discharge takes place as soon as the accumulated tension is high enough to overcome the resistance between the areas. A high point on the earth's surface is generally selected by the lightning, because whatsoever its nature it is usually, owing to the presence of moisture on its surface or in its pores, a better conductor than the air surrounding it. If it is a perfect conductor, or supports a perfect conductor of sufficient capacity in connection with the earth and with all adjacent metallic masses, the discharge passes from its extremity to its base without developing any noticeable phenomena; at any rate, nothing which is likely to cause danger to life or property, although it has been asserted that in the case of a very violent flash side discharges from the conductor of dangerous moment occur, in spite of the best earth connection. This, however, has been inferred rather from laboratory experiments than actually proved. If the precautions which I shall endeavour to prescribe and impress upon you as necessary are faithfully followed, such side discharges, should they happen, would probably be of inconsequence. A flash may very likely leap from the conductor to neighbouring masses of metal, if these are connected to earth and not to the conductor, especially if the earth of the conductor itself is a poor one; but so leaving them without a metallic link to the conductor would be a trifling with experience. On the other hand, if one or more sections of bad conductivity intervene between the summit and the earth, the discharge, although it will pass, will no longer do so harmlessly, but will develop explosive violence at the badly-conducting gaps. Its general course will still be the path of least resistance, but it may fly to and traverse any metal that lies in anything like a direct line between the summit and the earth, even if that metal only offers a path of a few feet. This tendency to leave the conductor will be increased proportionally as the earth connection is imperfect, a fact that will account, in the case under consideration, for the lightning striking the electric light wires; they, although covered and unconnected with the earth, offered the path of least resistance for a portion of the distance, and formed a connecting link between the point at which the lightning entered the dwelling and the point at which it left.

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* Paper read at the Edinburgh International Exhibition, September 5th, 1890, before the East of Scotland Engineering Association, by A. R. Bennett, Vice-President.

The enquiry seemed to indicate a discharge from the valley to the clouds *viâ* the telephone wires, electric light leads, chimneys and spires, the intervening air spaces within the house being jumped. The lightning, on this assumption, entered the wires at the stables by leaping from the old telegraph earth to the telephone terminals, and by piercing the insulation at and on each side of the stream. Arriving at the house, it jumped from the telephone terminals to the box containing the electric light fuses, and thence travelled by the leads into every room in the house. There it jumped to grates, pipes, and other metallic masses, and so to the metal of the roof, and away. A noteworthy point, and one which is replete with instruction to electricians is, that had the house not possessed telephonic connection with the valley it might, owing to its position on a badly conducting rock, have escaped altogether; and had it not had electric light and bell leads in every room it still might have escaped in spite of the telephone wires. On the other hand, had not such a golden bridge as was offered by the leads existed, a leap from the basement to the roof through the body of the house might have been attended by utterly disastrous consequences. But the accident does not teach that we should deny ourselves the advantages attendant on telephones and electric lights. It teaches rather that these conveniences may be a source of danger if inconsiderately and carelessly fitted, just as gas or stoves or lamps may become centres of danger if ignorantly or recklessly dealt with. When telephone wires, and especially metallic circuits, are taken into a building they should be fitted as near the point of entry as possible with a good lightning discharge. This necessity I recognised several years ago as a consequence of more than one accident, since when all metallic circuits constructed by the National Telephone Company have been so fitted. Such a discharger costing only a few pence, would in all probability have shunted the lightning to earth, and the inmates of the house might not have even been aware that a discharge had taken place. Telephones working with an earth return do not require such care as metallic circuits.

A discharge of lightning through a conductor may be roughly illustrated by hydraulic analogy. Let us suppose a long perpendicular pipe with a number of lateral holes at intervals, its bottom extremity opening into a large empty cavity. A mass of water caused to fall suddenly into its upper end would descend through the pipe into the cavity, and having no resistance but the friction of the pipe and the resistance of the air in the pipe to overcome, it would so fall without any, or but little, of the water escaping through the lateral holes. This answers to a lightning conductor of sufficient capacity having a good earth. A pipe of small diameter opening into a large cavity would represent a conductor of insufficient capacity though with a good earth. Through this thin pipe the water could only flow comparatively slowly, and the tendency to leakage through the lateral holes would be considerably increased.

Now, imagine a large pipe with an obstacle placed at its bottom so that the diameter is reduced one-half, or a large pipe opening into a cavity incapable of containing the water let down; then the water descending with a tremendous impact is partially stopped by the obstacle, or by the filling up of the cavity. The water will rebound and spurt violently out of the lateral holes. This corresponds to a conductor of sufficient capacity connected to an insufficient earth, and the effects will be exaggerated proportionally as the aperture at the bottom is reduced. If the same pipe is taken with the bottom end plugged up, the stoppage and spurting of the water will be greatly augmented, and perhaps the pipe will burst from the suddenly exerted lateral pressure. This answers to a conductor with a very imperfect earth. The analogy is striking here; the water, like the electricity, is seeking earth, its lowest level, but failing to find it through the pipe, spurts or bursts out laterally, and then recommences its descent by the nearest channel it can find. The water may have to turn corners and run down flights of stairs on the way, so the electricity may have to avail itself of anything conducting whether it lies directly in the path or not.

I now propose to detail the recommendations I have made with the view of preventing a recurrence of the accident at this particular house. The example is a peculiar one in more than one respect, but still the recommendations embody the precautions which, with variations due to local surroundings, are necessary in every case. The main object is obviously to provide a path of small resistance between the roof and the nearest earth. Owing to the rocky foundations of the house, this would seem to be at the stream in the valley and its vicinity, as the unusual mercy of a pioneer flash has clearly enough indicated.

The leaden roof with its spires which rise above everything may be left as it is, but seeing that rarefied air and soot are both conductors—comparatively poor ones, it is true, but still almost infinitely superior to air at the normal pressure—and that there are something like 40 chimneys opening above the roof, it is obvious that, taken collectively, the chimneys, especially when fires are on, present a conducting surface of very large area, and consequently of low resistance between the interior of the house and the atmosphere above it. When fires are burning this conducting surface may extend, in the shape of a column of rarefied air, considerably above the highest spire. To prevent the electricity selecting this conducting path of chimneys in paralled a better one must be provided, and this can fortunately be accomplished, as pointed out by Dr. Lodge, by erecting a skeleton cage of wire provided with a few pointed upright pieces above each group of vents, so that it may be enveloped by the rarefied air ascending therefrom. Each cage should have a soldered connection to the leaden roof, or by means of an iron wire direct to one of the conductors. These conductors may consist of at least four, preferably more, galvanised iron wires, No. 4 B.W.G., carried from soldered connections with the metal of the roof to the ground at as many different parts of the house, say at each corner, and at convenient intermediate points, and thence continued without break of continuity, and buried without boxing in a trench dug close to the boxing containing the telephone wires as far as the stream in the valley. The stables should be similarly treated, all the metal ridges of the roof, gutters, &c., being joined together by wire, at least one point projecting above everything else, and thence by means of two No. 4 wires laid in a trench also as far as the stream. There the water should be temporarily dammed back or diverted, and a hole excavated in the bed of the stream some 3 feet deep by 3 feet square. Into the hole a few bushels of retort carbon from a gasworks should be rammed; some 12 feet of each of the six iron wires—four from the house and two from the stables—should be coiled upon the carbon, then some more carbon well rammed down. Finally, the hole should be filled by well-rammed soil (not rock), and the water allowed to flow over it. If inconvenient to dam or divert the stream, the hole may be dug at one side of the water, and the water admitted over it when completed. There will then exist from the highest point of the house to the highest point of the stables a conductor making good earth at one place at least, and as good as the nature of the soil will permit at all others along the route, which is approximately that of the telephone wires. In the presence of such an arrangement, there would be no inducement for electricity to jump through several feet of air, and pierce thick gutta-percha insulation to invade the telephone wires. Further, in the house all systems of pipes or other masses of metal, such as grates, boilers, &c., should have connections with at least one of the conductors. Such connections may be of No. 5 B.W.G. galvanised iron wire, and should be soldered wherever possible. Of course, neither the electric light nor the electric bell nor the telephone wires can be so connected without interfering with their proper functions. This is a little unfortunate, but they may be dealt with by encasing a couple of feet of each of them in metal pipes, with India-rubber or porcelain rings between the leads and pipe, so as to make actual metallic contact impossible, while, at the same time, providing the shortest possible path for lightning between the three sets of leads. This would be attained by connecting the three lengths of pipe together and to the conductors by means of a No. 5 galvanised iron wire, soldered. In addition, the telephone wires should be fitted with an ordinary discharged at their place of entry. The object of these branch connections is, of course, to prevent any jumping in the house, whatever may happen in the future. If the main earth connection became insufficient from any cause, the lightning would again make for the stream *viâ* the telephone wires; but if all metallic masses in the house, and the light and telephone wires, are treated as described, it would do so without any dangerous discharge. The only jump would be across the air space between the tubes and leads inside them and through the insulation, and this would be entirely harmless.

I recommend iron wire because—for the theoretical reasons adduced by Prof. Hughes and Dr. Oliver Lodge, into which I have no time to-day to enter, and with which many of you are no doubt perfectly familiar—iron is now widely admitted to be as effective as copper for currents appertaining to the character of lightning, and because iron has been employed habitually in America, in France, and elsewhere for a long period, and there is no evidence forthcoming to show that the percentage of accidents in those countries has been greater than in Great Britain, which has hitherto adhered rigorously to copper. True, some authorities still advocate the use of copper, but the greater cost of that metal precludes its employment so liberally about a building as could be wished, and when the greatest use has to be made of a certain sum, I consider, theoretical reasons apart, that it is beyond comparison wiser to invest that sum in six or eight iron conductors than in one or two copper ones. Copper would be preferable, on account of its greater durability when buried, but still galvanised iron will endure for years when so treated. Theoretically, a conductor of flat section like hoop iron would be better than wire, but it is more liable to decay. In addition to such conductors as described being fitted, the existing drain pipes should be connected to the roof by soldered wires or bands, and connected at the lower extremities to the conductors by a No. 5 galvanised iron wire, carried round and soldered to each of them; and a flagstaff standing about 20 yards from the house should have an iron wire run up it and connected to the conductors. In fixing the cables, sudden bends or changes of direction should be avoided. If all these precautions are taken, and the connections are examined from time to time, and repaired when necessary, the chances of another visitation from lightning will be very remote.

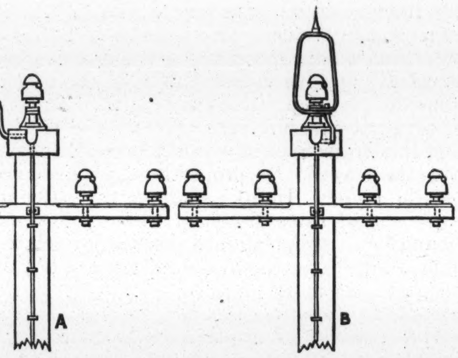
As before remarked, the recommendations are designed for a special case, and would not be applicable in all their details to many others. Still, to secure immunity from lightning, certain invariable precautions have to be taken in all cases. These are specially, firstly, having at least one metal point—multiple points are much better—in as perfect connection with the earth as possible, preferably by several paths, raised above all stone, wood, and other non-conducting portions of the building. These points should be preferably over or quite close to the chimneys, unless wire cages are provided specially for them. Secondly, connecting all pipes, grates, bell wires and other masses of metal in the house to the conductors, preferably by means of soldered connections; when this cannot be managed, as with light and telephone leads, then by providing a small air space across which the discharge may jump harmlessly. Thirdly, by securing a good earth. When a house is built on rock, or on a thin stratum of soil over rock, or on chalk, this point respecial attention and study. Where gas and water pipes exist, they should be joined to the conductors both above and below ground, and gas and water meters should be bridged by soldered No. 5 wire. Even when water pipes exist Dr. Lodge considers it better to provide a separate earth for the conductor, also attaching it to the pipes, but this is a refinement I have not myself adopted when good water mains, always full, and jointed with lead, have been at hand.

These are the three important points to keep in view in designing protective systems for buildings, and the architect or engineer should see personally that his design is carried out. If such precautions were general, we should hear less of mysterious fires than we do.

One thing has been brought out over and over again in connection with lightning conductors. Ordinary workmen are quite untrustworthy, and require constant supervision.

In conclusion, I am able to show you some effects of a recent lightning storm, which emphazise the necessity of having the highest point of any structure earthed. Last month a telephone wire erected on the tops of poles between Murtle and Cults, in Aberdeenshire, was struck. The wire was out of use, and was insulated at both ends, so that the lightning found no vent at the the extremities. It accordingly struck through the solid porcelain insulators to the iron bolts supporting them, and jumped thence to the earth wire, which was stapled up the poles to within an inch or two of the bolts. It shattered the insulators on the 1st, 2nd, 7th, 15th and 35th poles, counting from Murtle. At three of the poles the wire, No. 18 B.W.G. silicium bronze, was fused, and at the foot of one pole the earth was distributed and the grass burnt. Three of the insulators with fragments are on the table before you; the others were reduced entirely to small pieces, many of which could not be found. On one of those before you a metallic deposit from the fused wire is distinctly visible. Had each pole carried an earthed point raised above the topmost wire, the discharge would, almost to a certainty, have neglected the path of far higher resistance through the wire and porcelain, and all damage would have been avoided.

This is a weak point in our telegraphic practice, common to post office, railway, and telephone companies, and one which I have raised my voice against for a good many years past. In the figure, A shows the ordinary method of terminating the earth wire, which leaves the topmast line unprotected, and B the method I have adopted with the object of shielding it.



In house practice the analogy to the short earth wire is a system of gas or water pipes, bell or other wires, extending up to, say, the attics, with a non-conducting structure of plaster, wood, and slates intervening between the highest point touched by the metal and the air of the house. This non-conducting stratum absolutely does not exist when lightning is in question, and in the event of a discharge occurring between the metal in the house and the clouds above, would be shattered and scattered just as you see these insulators have been. It is a curious question what the precise nature of the force is that splits porcelain in the manner shown. The destruction of trees and telegraph poles by lightning has been attributed to the sudden generation of steam in the pores of the wood, due to the heat of the discharge or to expansion by the heat of the air which the wood contains; but in porcelain there is neither moisture nor air; yet, as you see, when it chances to intervene in the path of the least resistance, that does not prevent it from being split up and utterly destroyed.

Lighting at Southampton.—Messrs. Crompton & Co. are erecting the central station of the Southampton Electric Light and Power Company, Limited. Current will be charged for by meter.

UPON THE PERFORMANCE OF SIMILAR SYSTEMS OF DIFFERENT DIMENSIONS.

By W. MOON.

IN studying the different effects produced by similar systems of different dimensions, it is sometimes convenient to speak of the system being increased in all its dimensions D times and producing an effect of D^n times.

Thus the gravitational force between two bodies is proportional to the product of their masses directly, and to the square of their distance apart inversely, and, therefore, if the two bodies and their distance apart is uniformly increased D times, then the force between them will be increased

$$\frac{D^3 \times D^3}{D^2} = D^4 \text{ times.}$$

In a similar manner take two magnets that are small as compared with their distance apart, then the deflective force of the one upon the other will be proportional to their masses directly and inversely as the cube of their distance apart, and, therefore, with several such systems the deflective force exerted by each is proportional to

$$\frac{D^3 \times D^3}{D^3} = D^3,$$

provided, of course, that all the systems have the same magnetic intensity.

The force between two electrically charged bodies $= \frac{q \times q_1}{d^2}$, so that in similar systems of different dimensions charged to the same surface density the force is proportional to

$$\frac{D^2 \times D^2}{D^2} = D^2.$$

The distribution of the charge over the bodies would remain uniform only when the surface density was constant, whatever the dimensions. That is when the potential of the charge varied as the dimensions.

The gravitational force of a body at a point when the body together with the distance of the point are uniformly increased D times is proportional to D.

The intensity of field produced by magnets of different sizes, but of the same intensity of magnetism, is constant at similar points whose distances from the magnets is proportional to their dimensions.

Similarly the electric force of charged bodies upon points at distances proportional to the dimensions of the body is the same when the bodies are charged to the same surface density.

The kinetic energy generated by gravity in forming a body, or system of bodies, by bringing up the particles of matter from infinite distance would be proportionl to D^5.

The potential energy of bodies charged to constant surface density is proportional to D^3, that is, it is equal to half the product of the potential and the charge $= \frac{D \times D^2}{2}$.

The energy expended in magnetising a permanent magnet is also proportional to D^3.

The difference between these three effects is interesting.

While kinetic energy is generated in bringing together the particles of a body by gravity, on the other hand, potential energy is created in giving a body a static charge of electricity, and in the case of a permanent magnet energy is expended in its magnetisation which is not again recoverable. In the last case the energy expended is proportional to $\frac{I^2}{2}K$ where "I" is the intensity of magnetisation and "K" the coefficient of susceptibility.

However, in the case of a temporary magnet the energy is recoverable and is proportional to

$$\frac{1}{4\pi}\frac{H^2}{2} + \frac{I^2}{2}K = \frac{1}{8\pi}H.B.$$

per unit of mass.

Although the size of the field produced by a magnet is proportional to the magnet's size or D^3, yet the portative force is proportional only to the area or D^2. This is natural since the strength of materials is proportional also to D^2, and, like the strength of magnetism, is limited also by a coefficient.

The strain of torsion that any material will bear is proportional to D^3, or to the area when the leverage increases as D.

Therefore it follows, that with either belting or shafting the power transmitted with constant linear velocity is proportional to D^2 or to mass$^{\frac{2}{3}}$ if the length of the shafting increases as its dimensions.

In a similar manner power can only be transmitted by a current of electricity in proportion to the area of the conductor when the fall of potential per unit length is the same and the current is proportional to the sectional area of the conductor. But when the heat generated by the current is taken into consideration, the transmission of power by electricity is at a disadvantage as compared with other means, since for a conductor heated to constant temperature the power transmitted is proportional only to $D^{\frac{3}{2}}$ when the fall of potential per unit of length is constant, and it is necessary to make the fall of potential per unit length equal to $D^{\frac{1}{2}}$ before the power transmitted is proportional to D^2.

If the amount of heating of the coils of electromagnets, whose cores are similar in shape but of different sizes, is the same, then for the same induction through the cores the amount of copper upon the cores is proportional only to D^2, while, of course, the weight of the cores is proportional to D^3. The rate of expenditure of energy in the coil is also proportional to D^2, that is to the surface.

If, however, the depth of the coils upon the cores is proportional to D, instead of being the same depth upon the different cores, then the rate of expenditure of energy in the different coils would be proportional only to D. Of course the former of these methods should be used if it is desired to make the amount of copper used a minimum. But if it is required to have the resistance of the coil or the rate of expenditure of energy therein a minimum, then the latter method of having the amount of copper proportionate to the iron should be used.

If both the conductor and the iron of an armature of a dynamo vary uniformly as the dimensions; then when the conductor in each case has the same linear velocity, the E.M.F. generated will be proportional to D, and the resistance of the conductor to $\frac{1}{D}$ and if the external resistance also varies as $\frac{1}{D}$, the current generated would be proportional to D^2 and the heat given off in the armature and the work performed would be proportional to D^3. But the radiating surface of the armature is proportional only to D^2, and it is not therefore possible for a dynamo to have an output proportional to its mass if its heating is considered.

Again, since it is generally necessary to have the different dynamos give the same E.M.F., then the resistance in each case will be proportional to $\frac{1}{D^3}$ and if now the current is made proportional to $D^{\frac{5}{2}}$ that is to (sectional area of conductor)$^{\frac{5}{4}}$ then the heating of the armature will be proportional to D^2 or to the radiating surface, while the output would be proportional to $D^{\frac{5}{2}}$.

The output of dynamos, then, as a general rule will be proportional to $D^{\frac{5}{2}}$. And since the dynamo and electromotor are reversible it follows that the work an electromotor will perform is also proportional to $D^{\frac{5}{2}}$.

In the alternating dynamo the power required to maintain the magnetism of the field magnets would of course be the same power of the dimensions as in the direct dynamo. If the amount of iron and copper on the armature coils both increased as D^3 while the linear velocity of the machine was constant; then the E.M.F. would be proportional to the area of the armature coils to the angular velocity, and to the number of turns on the armature coils $= \frac{D^2}{D} = D$ if the number of turns is constant, or $= \frac{D^2}{D \times D} = 1$ if the length of wire on the armature coils is constant. Now, if the current in the first case is regulated to $D^{\frac{3}{2}}$, or in the second case to $D^{\frac{5}{2}}$, then in each case the rate of heating of the armature coils would be proportional to D^2, and the output of the machine to $D^{\frac{5}{2}}$.

Of course the size of a dynamo of a particular type and having a constant electromotive force and magnetic induction is limited by the fact that the conductors of the armature ultimately become as few as the bars of the commutator. Again, for electric lighting purposes the time of an alternation of current must not be greater than a certain amount, for this reason large alternating dynamos are constructed of a number of small coils instead of a few large ones. If it were possible to give large alternating dynamos the same angular velocity as to smaller ones, it would not of course be necessary to thus multiply the number of coils, but this is mechanically impossible since the centrifugal force would then be proportional to D^4, while the strength of materials resisting this force would be only proportional to D^2.

It is interesting to compare the performance of dynamos with that of the steam engine.

Thus suppose a boiler and its steam engine to be uniformly increased in all their dimensions whilst all the linear velocities are kept constant. As the draft is of a constant velocity the amount of fuel consumed in the furnace is proportional to the area of the grate, that is to D^2, and therefore the rate at which steam is generated is proportional also to D^2. The steam being at constant pressure, the thickness of the boiler plate and the strain upon it would be proportional to D, since the strain would be proportional to the circumference of the boiler. In like manner the thickness of the pipes and of the cylinder of the engine would vary as D, and be in proportion to the strain upon them. And since the pressure upon the piston rod of the engine is proportional to its area or to D^2, therefore the strain upon the piston, its connecting rods and shafting, belting, &c., would be proportional to their strength. Now, the piston having constant linear velocity the rate of performing work would be proportional to D^2 or (mass)$^{\frac{2}{3}}$ or (size)$^{\frac{2}{3}}$.

If, however, the linear velocity could be made proportional to D, that is, if the angular velocity and the time of a period of the engine is constant, the work the engine would perform would be proportional to D^3.

But just as the pressure of the steam is limited by the strength of the material of the boiler, so the linear velocity of the piston is ultimately limited by the velocity of the steam, so that it is only within very narrow limits that the power of a steam engine can be made proportional to its mass.

Also, as with the dynamo, so with the steam engine, the centrifugal force and the strain due to change of momentum with constant linear velocity is proportional, D^2, that is proportional to the strength of the materials to resist the strain. But with constant angular velocity, these forces would be proportional to D^4.

The capacity of similar boilers of different sizes is proportional to D^3, while the rate at which the fuel is consumed is proportional to D^2, therefore, the time of getting up steam is proportional to D. Also, since the mass of the moving parts of a steam engine is proportional to D^3, while the accelerative force of the pressure of the steam upon the piston is proportional to D^2, therefore, the time of starting the engine is proportional to D. The same, of course, applies to the time of starting a dynamo or any motor.

In similar electro-magnets of different sizes, the time of acquiring its magnetism or its time constant, is proportional to its dimensions, since its electro-magnetic inertia is proportionate to D^3, while the force accelerating the magnetism of the electro-magnet is proportional to D^2.

THE TELEPHONE IN AMERICA.

THE development of telephonic enterprise in the United States presents many interesting features, and not the least worthy of consideration is the important position in business and domestic relations occupied by this method of communication. The promptitude with which our American cousins grasped the full meaning of the advantages and possibilities presented by the telephone, and the rapid and enormous extension of telephonic systems throughout the States, stand out in strong contrast with the slow and hesitating procedure of European countries. The electric telegraph is credited with having completely changed the methods of conducting business formerly in vogue; the telephone is responsible for a no less thorough revolution in the mode of intercourse—social, domestic, and commercial, as conducted in towns and cities.

The history of the telephone in America is practically the same as that of the American Bell Telephone Company, of Boston, and a brief account of the operations of this association may be of interest to those of our readers who have not made a special study of the matter.

The telephone was brought into a practical shape by Graham Bell in 1876, and the original patent, and all subsequent ones, both as regards the telephone and the microphone, were acquired by the American Bell Telephone Company, who thus became almost the exclusive possessors of all telephonic and microphonic appliances and installations in America.

Up to the year 1887, the company worked its patents by leasing the right of using the telephone to various associations, under certain conditions, and over defined areas. These companies paid an annual tariff of $20 per instrument (including receiver and transmitter) hired, in addition to a charge of 25 per cent. of their receipts for the use of conduits.

The earlier concessions granted to the working companies were limited to a period of five years, and were then renewed only on new conditions. The concessionaire companies were obliged to place in the hands of the Bell Telephone Company 25 per cent. of their share capital, and at the same time were granted a reduction of 40 per cent. on the annual charge for hire of instruments. The working companies founded under these conditions have entered the third renewal of contract, so that the Bell Telephone Company is at present owner of more than half of the capital invested in telephonic enterprise in the United States.

In 1887 the Bell Company took another step in the direction of securing monopoly, by founding the American Telegraph and Telephone Company (the Long Distance Telephone Company), which undertook, with the capital of the parent association, the establishment and working of telephone lines connecting the larges towns to one another. The present system of this company embraces all the important towns from Buffalo to Washington, and the lines are being extended westward to Chicago, and in the south-west between Philadelphia and the Pennsylvania coal and oil districts.

The original patent acquired by the Bell Company expires in 1893, and in order to make competition as difficult as possible, the company has bought up all patents which are considered likely to be of practical utility. The company has also become the principal shareholder in the Electrical Subway Company of New York, and since new companies encounter great difficulty in obtaining the necessary authorisations for laying down their conduits, competition in this direction is not to be much dreaded. We may here mention that the annual charge for the use of these conduits is fixed at $850 per mile for a telephone cable containing 50 double conductors.

The Bell Telephone Company, in its report for the year ending December, 1888, gave the number of offices under its control as 742, in addition to 452 branch offices, the length of lines as 170,471 miles, of which 17,038 miles are underground, the number of instruments leased out as 411,511, and the number of subscribers 171,454 (now considerably over 200,000).

The overhead lines in America, whether for electric lighting, telegraphy, or telephony, generally leave much to be desired with regard to construction and maintenance. The lines of the Long Distance Telephone Company set, however, a good example in these respects, their wires being the only ones which withstood the terrible snowstorm of March 12th, 1888. Their lines have a total length of 1,491 miles, with 39,776 miles of conductors. The wires are of drawn copper 3 mm. in diameter; the posts average 40 to the mile. Among the more important lines are those between Buffalo and Rochester, 69 miles; Buffalo and Syracuse, 99 miles; Buffalo and New York, 497 miles; New York and Boston, 253 miles.

As an example of the insulation of these lines we learn that tests taken on the New York and Boston line, 253 miles in length and having 120 conductors, gave an average insulation resistance of 208 megohms per mile of conductor.

ON MAGNETIC CIRCUITS.

By H. E. J. G. DU BOIS.*

A CONSIDERABLE extension of our knowledge of magnetic induction has lately taken place. This, like many other additions to the realm of science, was chiefly called for in order to meet the wants of designers of electric machinery; and it has accordingly been arrived at in an essentially practical way. The aim of this preliminary communication is to show how physical science may draw advantage from some of these results, and may obtain them by unobjectionable purely physical methods. In doing so I shall not so much use the conception of lines of force, but shall rather start from the consideration of magnetisation. For it is the latter quantity, which for experimental reasons (*Phil. Mag.* [5] xxix. p. 303, 1890) I believe must be taken as the fundamental one from the physical standpoint, much more so than induction, to which such importance has lately been attached.

The idea of an analogy (even when only in mathematical treatment) of magnetic systems with other systems of fluxes (hydrokinetic, thermal, electric) dates back as far as Euler. Faraday (and following him Maxwell) and Sir W. Thomson then each developed it in his own way. It has been worked out and practically applied, however, during the last decennium.

Bosanquet (1883), Rowland (1884), W. v. Siemens (1884), Gisbert Kapp (1885), especially consider the analogy with the flow of electricity, and accordingly apply Ohm's law to magnetic circuits. As, however, this law essentially implies the resistance being constant, independent of the current flowing, the above extension of its most characteristic meaning can hardly be conceded from the physical point of view; nothing is thereby meant to be said against certain practical advantages gained by introducing an (essentially variable) magnetic resistance. Quite lately, again, Pisati (1890) has laid much stress upon the analogy with thermal circuits, and accordingly has applied Fourier's law to certain magnetic systems. This appears perhaps less objectionable in so far as thermal conductivity is not necessarily a constant as its electric analogue is, though Fourier originally introduced the former as such. But even then it depends upon temperature, not upon its space-variation or upon the flow of heat: the analogy is therefore in no case a complete one, magnetic conductivity being of course independent of magnetic potential.

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* Translation communicated by the Author to the *Phil. Mag.* for October, 1898, being the abstract of a paper read before the Physik. Gesellschaft, Berlin, June 27th, 1890.

No physical objection, however, appears to exist to the totally different treatment the question received at the hands of J. and E. Hopkinson (1886): they started from two safely established mathematical propositions, and only made some auxiliary assumptions in order to simplify the (approximate) calculations. In this way they so arrived at their graphic construction, now used to a certain extent in machine design, and which will be reverted to below.

Poisson's old theory of magnetic induction, extended by Neumann and Sir W. Thomson, as laid down *e.g.* in Maxwell's treatise, is known to rest on the fundamental assumption of constant susceptibility; it therefore applies to all substances except "ferromagnetics" (iron, cobalt, nickel, magnetite, and any substance which may yet be found to behave similarly). Kirchoff then introduced a new theory (in 1853) by making the more general assumption that magnetisation is a function (capable of experimental determination) of the total magnetic intensity. Besides the important solutions of certain particular cases (ellipsoid, closed ring), he restricted himself to giving a few integral equations in the place of Poisson's. However, these were of but little practical use, and are hardly more so now that Duhem has lately taken up the analytical problem anew.

A more geometrical treatment of the new theory showed the distributions of the vectors concerned to be as follows:—(*a*) magnetic intensity: lamellar; (*b*) magnetisation: complex-lamellar; (*c*) induction: solenoidal; (*d*) also the three vectors are easily seen to have the same direction at every point. The proof and further discussion of these propositions cannot be given here. It may be remarked that homogeneous, isotropic ferromagnetic substance is assumed, through which no electric currents are supposed to flow; neither is hysteresis taken into account.

The simple type of a circuit not completely closed is a thin ring containing a radial air gap and subjected to a uniform tangential magnetising force. This particular case, a solution of which has to my knowledge never been attempted, is reducible to the known case of an ellipsoid of revolution. In fact, it is only necessary that the "self-demagnetising factor" be capable of calculation; *i.e.*, the number into which the magnetisation has to be multiplied in order to obtain the intensity of the self-demagnetising effect. Let this numerical factor be, as usual, denoted by N; for sufficiently long ovoids (prolate ellipsoids of revolution) of axial ratio, m, it is found by the well-known equation

$$N = \frac{4\,\pi}{m^2}\,(\log_e 2\,m - 1).$$

Now let the gap of our ring have the angular value a; *i.e.*, an arbitrary concentric circle in it being considered, the $a/360$ part of this will lie in air, the $(360 - a)/360$ part in the ferromagnetic substance. A consideration of the line integral of the self-demagnetising intensity, which must vanish along any such closed circular line of integration, leads as a first approximation to the result that

$$N = \frac{4\,\pi\,a}{360 - a}\ [\text{approx.} \div {\cdot}035\,a].$$

The proof cannot well be given without a diagram. Both particular cases are now comparable in every respect, as the following short table shows:—

Ovoid. m.	Factor. N.	Ring. a
20	·0848	2°·41
30	·0432	1·22
40	·0266	·76
50	·0181	·52
100	·0054	·15
∞	0	0

Now Lord Rayleigh has given a graphic construction for ovoids, which Ewing expresses in the following words:—From the ordinary curve of magnetisation for infinitely long ovoids, that corresponding to a given finite one may be obtained by shearing the diagram parallel to the axis of abscissæ through an angle, which is simply determined by N, therefore also by the given ratio of axes. By the above the curve for closed rings may now, in the same way, be sheared into a diagram for a ring with a given angular gap.

The analogy of this process with the Hopkinsons's well-known graphic method is obvious, though at first essential differences appear to exist; *e.g.*, the quantities used for co-ordinates are not the same in both cases. However, a comparison in detail finally leads to the identification of both constructions, so that in any given particular case the curves would exactly overlap, supposing the co-ordinates to be measured to proper scales. Our problem, a solution of which was first necessitated and afterwards approximately given by machine practice, has therefore now been solved to the same order of approximation by physical methods.

The degree of this approximation, the allowable limits for thickness of ring and width of air gap, the amount of "leaking" of lines of force, &c., can only be determined by experiment on as large a scale as possible.

STREET RAILWAY MEN IN CONVENTION.

Cross-examining Electricians. Revelations.

UNDER the presidency of Mr. J. N. Partridge, the Street Railway Association of the State of New York held its eighth annual meeting on the 16th ult., at Rochester. The President, in his address, dwelt upon the marked progress that had been made since the last meeting by the substitution of mechanical and electrical devices for the propulsion of street cars in the place of horses. This address, whilst setting forth some of the advantages of electric traction contained nothing of special interest, and it was followed by a paper "On an Electric Street Railway Motor," read by Mr. J. W. McNamara. This paper, the only one presented to the meeting, was very short, concise and to the point; it referred to the conversion of a horse car line at Albany into an electric one, by the Thomson-Houston Company. The contract was given out on the last day of November, 1889, and on May 1st, 1890, all the horses on that line were withdrawn. None of the drivers had had any training until the evening of April 27th, 1890, yet they were able to begin running schedule trips with three cars the next day. Four months' experience has taught the author that the electric motor is efficient and reliable, but he has yet to learn that it will ascend an 8 per cent. grade at the rate of 5 miles per hour in winter as it did in summer. The question as to whether the electric motor is as economical as the horse cannot yet be answered, and need not be answered—so says the author in concluding his address.

The "discussion" which followed was remarkable, for several reasons: in the first place hardly any reference was made to the paper read; secondly, the speakers, mostly representatives of contractors, referred to the advantages of their respective "systems," somewhat depreciating those of rival concerns; and, thirdly, for the cross-examination which certain electrical experts had to undergo, which revealed some interesting facts.

Mr. Frank Rogers, representing the Short Electric Railway Company, of Cleveland, stated that the "series" system has been abandoned by his company, and that they used now the parallel system, like Thomson-Houston and Sprague. Questioned by several gentlemen as to the reasons why the "series" system has been abandoned by its own inventors and former advocates, Mr. Rogers explained that it could only be worked successfully with two or three cars, but with more than five on the line it was a failure. The trouble was, that it was difficult to manufacture a constant current generator that can be operated with little attention. "The generator fluctuates, so that it does not take care of the current." In the parallel system the electromotive force is constant. In the series system the current should be, but is not, and for that reason it is not adapted for a large number of cars. The construction of the conductor was too complicated, a switch being used in it. Prof. Short, the originator of the "series" system, had studied the question very carefully, and has spent a great deal of money in trying to work the system up and make it a success, and has also experimented largely in underground work before the new company was organised; but since then the parallel system has been adopted.

Mr. Rogers prefers the single overhead wire and rail return; it is not so complicated, and in a large city where there is one line crossing a number of tracks, it lessens the number of wires overhead. At Cincinnati they were obliged to put in the parallel double overhead wire on account of the telephones there, and the street railway managers being largely interested in the telephone companies. Many other questions of less importance were addressed to Mr. Rogers and satisfactorily answered, when Mr. E. E. Higgins, of the Sprague Company, which is now part of the Edison General Electric Company, was called upon to give his version on the subject.

Mr. Higgins claimed that the principal things brought out by Mr. Sprague, and copied ever since, were the placing of the motors underneath the cars, and attaching them to the axles on one side, and to a spring support on the other. Then the control of both motors of the car from either platform was another important point. The method of winding the Sprague motor field, says Mr. Higgins, is entirely different from all others. They are wound in three sections each; the control of speed is effected by different combinations of these coils without the use of wasteful resistances. The consequence is that the cost of coal per car is less than with any other system. Mr. Higgins does not seem to be aware that all these points, which render the Sprague system so superior, were invented and applied by Mr. A. Reckenzaun long before, as can be readily seen by Mr. Reckenzaun's patent specifications, 1882 to 1885, as well as by numerous papers read, and articles in scientific journals. The claim to the conception of the under running trolley, Mr. Higgins believes, is disputed, and presumes that it is one of those early contrivances which may have been brought out by others at the same time. It has been adopted everywhere, and is the only true way of getting at the root of the matter. Since August 1st, Mr. Edison had been devoting his entire attention to some changes in the motor. They referred merely to mechanical details. The fields of the motor are now spread slightly, so as to allow of more wire on the cores. The gears have been widened, but the most important advance which has recently been made in electrical railway work is the adoption of the new style of winding the armatures. The old armatures were wound in accordance with what is called the Siemens method; the wires at the ends of the armature are in a bunch, crossing and recrossing each other, and not being firmly fastened in place, there is necessarily some chance for the play of wires, and this results in the armatures frequently burning out. The first effect of this method is that there may be a maximum pressure wire touching a zero pressure wire, and the slight motion between these two will cause the insulation to become abraded, and a short circuit follows. In the new armatures the coils are wound separately, and there is no bunching of wires at the ends. No definite description of the winding is given; but if the "drum" armature is adhered to, we presume the ends will be arranged on a plan similar to that devised by Mr. Crompton for his dynamos.

Mr. Norman McCarty, of the Thomson-Houston Company, mentioned that his firm had long recognised the fact that the electrical railway apparatus is not so much an electrical as a mechanical problem. They use plain series-wound field magnets, and have made up their minds that it is a good deal better to spend a little more for coal, and avoid wear and tear. This company uses the much-abused rheostat, which has the advantage that the car can be started without a jar. Regarding line construction, the Thomson-Houston Company is not limited by any patent, the method of construction varying with the conditions of the circuit. There is a patent on a system by which the line is fed at regular intervals; there is no patent on the ordinary system used.

Interrogated by Mr. Richardson, Mr. McCarty stated that he could not explain the superiority of the Thomson-Houston system over the Sprague system without criticising the latter. The Thomson-Houston cars and trucks were heavier, the motors heavier and stronger built, the gears were wider, and electrical complications were eliminated. He did not care about electrical theories so much as mechanical perfection, and that was the secret of his company's success.

Mr. Richardson asked purely for information, as he represented several tramway companies which were contemplating the purchase of electrical apparatus, and had not purchased a thing yet. He called attention to the fact that a leading Boston newspaper sent out letters asking for information from all cities in which electric railways were operated, enquiring what systems they used, whether there had been any loss of life in connection with the wires, whether there was any objection to the overhead system on the part of the public, and what had been the effect on the street railway service of the particular locality. Answers had been published, so far as received, from 64 different places, and all but four of them were favourable to electricity. Nashville, Tenn., was the only place where there was any loss of life reported, and the answer from that place was very amusing. There had been a wire broken in the city, causing the death of a horse, and a negro woman caught up the wire and threw it over, and it gave her a shock that was very funny in its effects, but did her no injury. It killed the horse, but it did not kill the woman, going to show that it is easier to kill a horse than it is to kill a human being, especially a "nigger."

Another objection came from Newport, R.I., where the "upper ten" were objecting to anything which should popularise riding.

Mr. F. R. Chinnock, in referring to complaints on the part of telephone companies, said that the simple way to prevent induction caused by electric railway wires is to provide a return metallic circuit; but suggests that the telephone people should go to this expense.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.—LEEDS, 1890.

SIR WILLIAM THOMSON'S NEW ELECTRICITY METER.

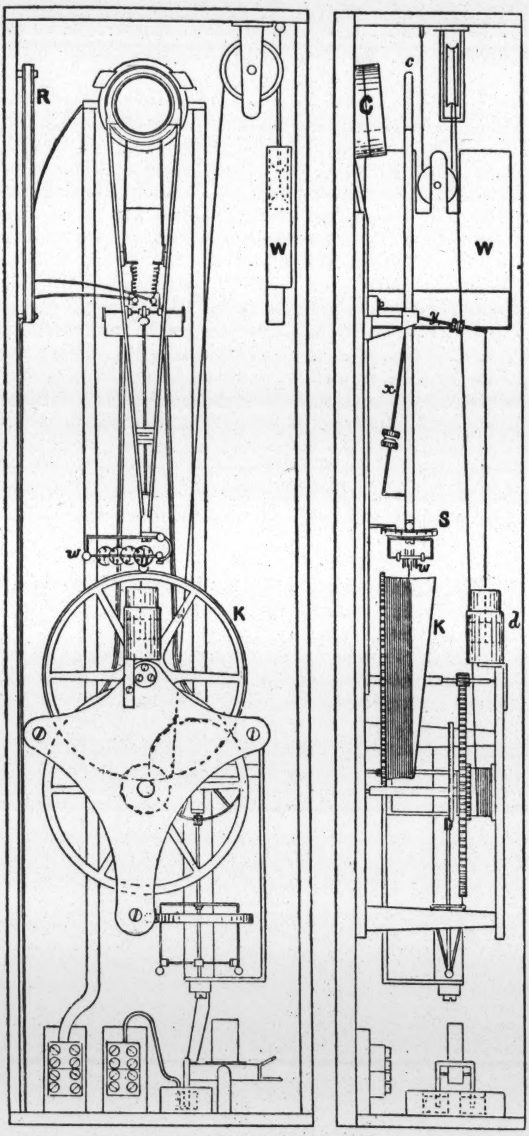
(*Read before Section G, September 8th,* 1890.)

THIS instrument forms at once an indicator, by which the strength of current passing at any given instant can be read off on a scale, and a supply meter, by which the amount of current that has passed through the meter during any given time is recorded on a train of counting wheels.

The indicator consists of a light aluminium frame, free to turn about a horizontal axis, having at its top end a coil of fine copper wire, *c*, and at its lower extremity a train of counting wheels, *w*. The frame is supported on knife edges, and a current is conducted into and out of the fine wire coil by two spirals of fine copper wire, H. The resistance of this coil is about 30 ohms and it is joined in series with an anti-inductive platinoid resistance, R, of 970 ohms. When the meter is in action a small current is kept passing through this circuit. The whole current to be measured is conducted through a fixed coil, c, of copper ribbon, which is placed with its plane parallel to the plane of the fine wire coil when the latter is in its zero position. A scale, s, divided to give readings in ampères is attached to the indicator, on which the strength of current passing through the fixed coil can be read off by means of an index fixed to the case of the instrument.

The recording apparatus consists of the train of counting wheels, w, mentioned above and a revolving cam, K, driven by clockwork which is kept in motion by a weight, W. The cam is kept revolving at a uniform rate, and, when a current is passing through the instrument, comes in contact at each revolution with a trailing wheel attached to the counting train which it causes to turn round; and so makes a record.

The action of the meter may be shortly stated as follows:—When no current is passing the indicator stands at 0 on the scale, S, the movable coil is about 1 millimetre from the fixed one, and the trailing wheel of the counter train is quite clear of the cam, so that no record can possibly be made. When a current is passing through the fixed coil, the top end of the indicator is repelled *outwards*, and the counting train of wheels is brought *inwards* towards the cam to a position depending upon the strength of current which can be read off on the scale. In this position, at the proper time of the revolution, the trailing wheel is lifted by the cam, and runs over a shorter or longer path in proportion to the strength of current passing. Thus, if the current passing through the fixed coil be 5 ampères the counting wheels might record 20 for every revolution of the cam, whereas were the current 10 ampères the trailing wheel would roll over twice as long a path and the record would be 40.



Two screwed rods are so attached to the indicator that one, x, is vertical, and the other, y, is horizontal when the beam is in its zero position. These rods are provided with adjustable nuts—those on the vertical being to adjust the sensibility of the instrument, while those on the horizontal rod are for the adjustment of the zero. By means of the former the constant of the meter can be quickly varied if found convenient. Thus a meter which is suitable for measurement from 1 to 20 lamps can be altered in a few minutes to suit ranges of from 1 to 50 or from 1 to 100 lamps. This adjustment can be made by an inspector without the use of any auxiliary instrument. All that has to be done is to hang on a weight of a given amount on the knife-edge stirrup at the end of the horizontal arm and raise or lower the nuts on the vertical arm till the indicator shows a given reading on its scale. By this means also the constant of the meter can be checked at any time.

As at present arranged the driving weight needs to be wound up periodically by means of a revolving disc on the front of the case. It is intended that this should be done by the consumer, and an arrangement is made by which the current is automatically cut off from the house when the weight is allowed to run down. Precautions are also taken to prevent any fraudulent tampering with the instrument.

ON THE VALUES OF CERTAIN STANDARD RESISTANCE COILS.

By R. T. GLAZEBROOK, F.R.S.

(*Presented to Section A, September 9th.*)

THE Standard B.A. units of the Association have during the year been several times compared together both by the secretary and by Mr. Fitzpatrick. Table I. gives the results of two sets of comparisons made in August, 1890. The differences between the various coils and the platinum silver standard Flat are given in the third column in bridge-wire divisions. One bridge-wire division is very nearly ·00005 B.A. unit.

TABLE I.

Resistance of the B.A. Standards, August, 1890.

Coil.	Temperature.	Difference between each coil and flat in bridge-wire divisions.		Observed calculated.	Change of resistance per 1° C. in b w.d.
		Observed Aug. 15, 1890.	From chart. 1888.		
A	17·2	27·8	33·0	− 5·2	28·6
B	17·4	30·5	30·5	0·0	28·8
C	17·6	22·2	23·0	− 0·8	14·2
D	17·25	61·2	63·5	− 2·3	61·7
E	17·3	79·2	79·5	− ·3	60·7
F	17·3	3·2	− 9·5	12·7	5·7
G	17·5	− 22·0	− 18·0	− 4·0	5·5
H	17·4	− 17·0	− 15·0	− 2·0	5·6
		August 19			
A	18·8	67·5	69·5	− 2·0	28·6
B	17·8	60·6	62·0	− 1·4	28·8
C	19·2	31·6	36·0	4·4	14·2
D	18·8	145·7	15·1	5·3	61·7
E	19·0	170·6	17·3	2·4	60·7
F	18·9	2·9	− 9·5	12·4	5·7
G	19·0	− 21·8	− 18·0	− 3·8	5·5
H	19·0	− 17·7	− 15·0	− 2·7	5·6

In the fourth column are given the corresponding differences obtained from the chart made in 1888. In the next column will be found the differences between the observed values and those given by the chart, while the sixth column gives the change in resistance for 1° C. for the various coils. It will be seen that for the first five coils the differences between observation and the chart are such as would be readily accounted for by a small error in the temperature, and we may say that there is no evidence of a change in the resistance of these coils relative to Flat. This conclusion is borne out by the results of a series of observations made in January and February by Mr. Fitzpatrick. But when we come to the three platinum silver standards, F, G, H, the results are at once seen to be quite different. Thus F would appear to have risen relatively to Flat by about 12·5 bridge-wire divisions, while G and H have fallen by 4 and 2·5 divisions respectively.

Since these are the most important standards, their temperature coefficients being all very small, it was necessary to examine their history with some care. A change in F had been noted in a postscript to the report for 1888. The general conclusions of that Report were that up to the summer of 1888 there had been no change in the value of the coils. It was shown that all the original platinum silver coils examined then—those of Messrs. Elliott, H. A. Taylor, and others, as well as those belonging to the committee—had apparently fallen in value relatively to the mean B.A. unit by about ·0007 B.A.U. since 1867, but evidence was adduced to show that the fall was only apparent and was due to an error in the temperature coefficient used at that date. A single observation of Chrystal in 1876 pointed to the possibility of a change in F, but that change was not confirmed by other evidence; while so far as the platinum silver coils were concerned, the observations of Dr. Fleming in 1881, and myself in 1888, agreed closely.

Since 1888, however, changes have shown themselves.

These are evidenced by the three following tables II., III., and IV., which give the differences Flat-F, Flat-G, and Flat-H respectively.

TABLE II.—*Value of* Flat-F.

Date.	Temperature.	Value.
Chart 1888	10·0	10·5
	15·0	9·5
	20·0	8·5
May 16, 1888	14·8	9·0
July 2, „	0·0	3·0
July 3, „	14·8	3·8
July 13, „	14·2	4·2
July 13, „	14·6	3·3
July 14, „	14·7	3·3
July 28, „	16·7	4·2
Jan. 27, 1890	10·0	−4·0
May 31, „	14·4	−3·5
Aug. 15, „	16·9	−3·2
Aug. 29, „	16·7	−3·0

TABLE III.—*Value of* Flat-G.

Date.	Temperature.	Value.
Chart 1888	10·0	17·5
	15·0	18·0
	20·0	18·5
July, 1888	14·6	16·6
Jan. 27, 1890	10·0	16·9
Jan. 29, „	4·5	16·7
Feb. 4, „	6·0	16·6
May 31, „	14·4	21·5
June 10, „	16·0	21·4
June 11, „	16·0	22·2
June 12, „	16·0	22·2
June 13, „	16·0	22·2
Aug. 9, „	19·0	21·8
Aug. 15, „	17·0	22·3
Aug. 29, „	16·5	22·6
Aug. 29, „	16·5	22·5

TABLE IV.—*Value of* Flat-H.

Date.	Temperature.	Value.
Chart 1888	10·0	15·5
	15·0	15·5
	20·0	15·5
July, 1888	14·6	14·1
Jan. 27, 1890...	10·0	17·5
Jau. 29, „	4·5	17·5
Feb. 4, „	6·0	16·5
May 31, „	14·1	18·3
June 10, „	16·0	18·1
June 11, „	16·0	17·7
June 12, „	16·0	16·4
June 13, „	16·0	16·8
Aug. 9, „	19·0	17·7
Aug. 15, „	17·4	17·0
Aug. 28, „	17·0	17·8
Aug, 29, „	16·4	18·2

The three first lines in each table give the differences at the temperature shown taken from the chart drawn in 1888; the remaining lines give the differences actually observed, with the dates and temperatures. Thus, taking the various coils, it is clear that while up to May, 1888, the difference between Flat and F remained the same as shown by the chart and observations up to that date, a change took place during the low temperature observations in July, 1888, while by the time the coils were again examined in January, 1890, a further change had manifested itself. This continues up to the present date, so that now at temperature of about 15 deg. the coil F has increased in resistance relatively to Flat by about 12·7 bridge-wire divisions. This, assuming the whole change to be in F, will correspond to a rise of resistance of ·00063 B.A. units, or, in other words, the temperature at which the coil is right has fallen by about 2·3°. In January, 1890, the coils were again exposed to a low temperature, and it seems probable that the changes took place when the coils were in ice.

Turning now to Table III., which gives the values of Flat-G, we see there is no evidence of change till May, 1890. The observations in July, 1888, and January and February, 1890, are quite in accordance with the chart, but in May, 1890, it is clear that G has fallen relative to Flat.

The value of the difference at a temperature of 16° is 22·1 b.w.d. as against 18·1 given by the chart. Thus G has fallen relatively to Flat by 4 b.w.d., or ·0002 B.A. units. This change was first observed after the coils had been exposed to a low temperature.

With regard to H the change first showed itself during the low temperature observations in January and February, 1890, and Table IV. indicates that the difference between Flat and H is now 17·5 divisions as against 15·5 in 1888, or in other words, that G has fallen by ·0001 B.A. unit. Also since Flat-F changed in 1888, while Flat-G and Flat-H did not, we infer that the change at that date was in F, not in Flat, while since Flat-H changed in January, 1890, without a change in Flat-G, it appears that the change was in H, not in Flat; and finally, from the observations in May, 1890, which show a change in Flat-G, but none in Flat-H and Flat-F, we infer a change in G.

As to the cause of these changes, we can say but little. We hope to investigate them more completely by the aid of the coils lent by Mr. H. A. Taylor and others, and referred to in the 1888 Report; but it seems possible that they are due to strains set up in the wire by the great contractions and expansions produced by cooling and heating in the paraffin in which the coils are embedded. The coil Flat is of a different shape to the others and little or no paraffin has been used in its construction. The other coils, F, G, H, are embedded in paraffin in the usual way. On cooling down to 0°, this shrinks greatly, and it is quite conceivable that this shrinkage may have strained the coils and so caused the change. We hope to test this by having coils made free from paraffin and investigating with them the effects of repeated heating and cooling. The fall of H and G would be accounted for by a loss of insulation causing a slight leak either from the wire to the case or across the surface of the paraffin. The insulation resistance for F, G, H, was therefore tested and found in each case to be several thousand megohms, while the surface of the paraffin which had become dirty with time, was scraped, but without producing any change in the resistance. A leak, of course, would not produce the rise found in F.

Observations of the coils at 0° have always been unsatisfactory and attended with considerable difficulty. This is mainly due, I believe, to the fact that the temperature of the room in which the observations have been made has usually been above zero, and that heat is conducted into the coils by the thick copper connecting rods. It would seem possible, however, that part of the difficulty (*See* Report of the Committee for 1888, Table VII.) may have been due to real changes in the resistance arising from strains set up by the cooling.

The Legal Ohm Standards.

The results of observations on the legal ohm standards of the Association are given in the Report for 1886. Experiments made in these between July, 1884, and January, 1886, showed that while one coil, C.L.C. 100, had retained its value unchanged, the other, C.L.C. 101, had varied. These observations have been continued, and the results are given in the following tables, which give the value of each coil as found by direct comparison with the standard B.A. units, and its value as given by the chart in 1886.

TABLE V.—*Results for C.L.C.* 100.

Date.	Standard used in comparison.	Temperature.	Value.	Value on Chart.	Difference.
Feb., 1887	F	16·3	1·00009	1·00008	·00001
Nov., 1889	G	15·8	·99997	·99996	·00001
„	„	14·8	·99971	·99968	·00003
„	„	16·0	·99998	1·00000	·00002
Dec., 1889	Flat	14·4	·99962	·99959	·00003
„	„	14·8	·99969	·99968	·00001
„	„	13·2	·99925	·99924	·00001
...	...	6·2	·99744	·99735	·00009
...	...	5·7	·99729	·99720	·00009

TABLE VI.—*Results for C.L.C.* 101.

Date.	Standard used in comparison.	Temperature.	Value found.	Value on chart in '85, '86.	Difference.
Feb., '87	F	16·3	·99970	·99930	·00040
Nov., '89	G	15·9	·99955	·99920	·00035
„	„	15·1	·99932	·99899	·00033
„	„	16·0	·99955	·99922	·00033
Dec., '89	Flat	14·4	·99909	·99880	·00029
„	„	15·0	·99925	·99897	·00028
„	„	13·3	·99879	·99850	·00029
...	...	7·6	·99725	·99695	·00030
...	...	6·5	·99701	·99668	·00033

These tables show three facts conclusively:—(1) That up to December, 1889, no appreciable change had taken place in the relative values of C.L.C. 100—the legal ohm standard—and Flat or G; (2) that between January, 1886, and February, 1887, C.L.C. 101, which had varied previously, changed by about ·0004 ohms; and (3) that the greater part of that change has remained permanent up to December, 1889. At present the difference between

C.L.C. 100 and C.L.C. 101 is about ·0004; in 1886 it was about ·0008. The agreement between the observations in November and December, 1889—in one set of which Flat was the standard of comparison, while in the other G was used—show that the relative change in G and Flat took place after this date.

DISCUSSION ON THE REPORT OF THE COMMITTEE ON STANDARDS.

(*Tuesday, September 9th*, 1890.)

THE following discussion took place on the report of the committee, and the papers by Prof. Fitzpatrick and Messrs. Glazebrook and Griffiths :—

Prof. **FitzGerald** said that he did not understand whether an attempt had been made to anneal the specimen of copper that gave the very abnormal density and low conductivity, or whether annealing would alter it. He also asked where the copper came from, because it would be interesting, in connection with the committee that had been appointed to make experiments on this abnormal copper, whose thermo-electric properties were also connected with this. He would like to find out where specimens could be got.

Dr. **Fleming** answered the questions of Prof. FitzGerald, stating that he had obtained the copper from Mr. Elmore.

Mr. **Swinburne** remarked that in some American books, for instance, they gave a figure something like 784 as the most recent determination. But if there was any chance of an error of 4 or 5 per cent. in that, he thought it would be important to determine it again.

Mr. **Fleming** said that one question raised seemed important in connection with changes in the coils, and that was the strains taking place in the wires as they were usually wound. Paraffin expanded and contracted during heating, and he was inclined to think that it would be better to use liquid paraffin. He was sure the members of the section fully appreciated the value of the work that Mr. Glazebrook was doing in keeping a careful watch on those coils for slow changes. Those coils constituted standards for all the world, and it was most important that a watch should be kept on them to detect normal changes. It was a most unfortunate fact that the standards were made of complicated alloys. The simple metals which would be better adapted for permanent standards having very high temperature coefficients. Some experiments had been carried out in the United States on alloys. One of these alloys was compounded some time ago by Mr. Weston, and Dr. Nicholls has published a paper on the matter. The alloys consist of copper nickel and ferro-manganese, and have a negative coefficient with change of resistance with temperature. It had been found that by suitable combination of these alloys it was possible to have an alloy that did not change its temperature. Unfortunately, however, these ferro-manganese alloys were not at all likely to be used, because they changed their resistance with small currents. His acquaintance with coil G had ceased for some time, but he had some recollection that that gold and silver coil gave them some anxiety. So far as he could follow Mr. Glazebrook, however, it was the coil F (platinum-silver) that had changed so much. This seemed to point to the necessity for more careful investigation of the changes of resistance and losses with time was required. With regard to the method of testing capacity with a revolving commutator, he had made experiments some years ago with satisfactory results. The commutator was driven by an electro-motor being keyed on to the motor shaft.

Sir **Wm. Thomson** was glad that Dr. Fleming had called attention to the loss of negative temperature coefficient, and said that it would be interesting for the section to know that the subject was under examination in Dr. Helmholtz's laboratory. If there was no temperature variation, they might soon hope to see coils in which they would not be troubled with any temperature error.

Mr. **Trotter** said that since the B.A. Committee were dealing with the resistance of copper, it might be important to determine what was meant by copper. Tempering produced a very large change, and the expression "thorough tempered" was used. But surely, if tempering did produce any change, they ought to know what was meant by "thorough tempering." It was perfectly well known that ordinary commercial copper contained a considerable amount of oxygen. The question arose, What amount of oxygen or hydrogen might be occluded in deposited copper. It was not a purely chemical question, and should be determined.

Sir **Wm. Thomson** remarked that the time occupied in thorough tempering was important. It might extend over hours, days or weeks, and might produce very different results.

Prof. **FitzGerald** said that that fact seemed to make the difference between pure and impure metals.

Mr. **Glazebrook** said that the numbers in Table II. gave the resistance of the same wire that had been tested there after it had been annealed. In the one column they had the resistance of hard-drawn wire, and in the other after annealing. The annealing was done by enclosing the wire in a flat copper case, packed full of asbestos and lampblack, heating it with a Bunsen burner, and leaving it for 24 to 26 hours. In every case the numbers in the table gave the results of more than one annealing. The process of annealing was repeated again and again, and the numbers gave the mean result of as perfect annealing as could be arranged for.

Sir **Wm. Thomson** suggested that the use of lampblack and the consequent presence of carbon might have a very important effect on the result, and he thought it would be well to try annealing with asbestos alone.

Dr. **Lodge** asked whether the section were to run away with the idea that there was something the matter with the platinum-silver alloy. Mr. Glazebrook had told them that the platinum-silver coil might be all right, but coil F had changed. He would like to know whether it had changed by more than one part in 10,000.

Prof. **Perry** remarked that in some observations which he had recently been making on wires, strips of the same wire, after being flattened and twisted, behaved in such a different way as regards their elasticity that they might almost be thought to be made of different material.

Lord **Rayleigh**, in connection with the impurities of copper, mentioned some experience he had gained during last summer. In passing pure hydrogen over copper wires at a red heat, he found that the gas reeked of sulphuretted hydrogen. It was impossible to get copper that did not give off sulphur. When the wires were taken out after heating, they were absolutely brittle, suggesting the idea that the removal of the sulphur had been fatal to their mechanical properties.

Mr. **Searle** having described the methods he had adopted for rotating the commutator,

Mr. **Glazebrook** replied to the questions and suggestions that had been made. With regard to what had been said as to annealing, he was afraid that in endeavouring to be brief, he had not been quite just to the very great care Mr. Fitzpatrick had taken on this point. There was a great feeling among copper manufacturers that a small amount of oxide was necessary to give density to copper wire, and there was a certain amount of oxide in all copper. The original reason why it was annealed in charcoal was to get rid of that oxide, and he fancied that in almost all cases the wire did turn out brittle. At the same time it came out with a very much reduced resistance. In Mr. Fitzpatrick's method of preparing the copper, the hydrogen was passed over the copper at a red heat for a considerable number of hours. Mr. Fitzpatrick had a specimen of copper prepared by chemical means, the results of observations on which he had hoped to have had there that day, had not the breaking of a tube (obtainable only in Germany) postponed the reduction and purification of the copper until another could be got. But he fancied the copper did become distinctly brittle, and lose its density when the sulphur was got rid of. As to Mr. Taylor's remarks about Matthiessen's knowledge of the temperature coefficient, he had his formula there, and he thought the number was obtained by ranging from 16 to 100. He had not been able to find any observations of Matthiessen lower than 16; if Mr. Taylor had numbers nearer 0, they would be extremely valuable to the report. Dr. Fleming had referred to the point he (Mr. Glazebrook) raised as to the effects of mechanical strain. It would be in the memory of the section that in the last clause of the report he asked for further resistance coils. It was his intention to wind these entirely without paraffin. As to the loss with negative temperature coefficient, they had been in communication with the Helmholtz laboratory, and they hoped to have specimens of wires before long. With regard to the platinum silver alloy, his impression was that there had been no change in the alloy, but that a mechanical change had been produced by strain, and he hoped that any electricians who had old coils of the Association would lend them to him again that he might compare them, and see if there had been any change. The amount of change in F was a rise of

+ ·0007 B.A. unit.
G − ·0002 do.
H − ·0001 do.

He thought Prof. Perry's remarks entirely bore out his experiments. Mr. Searle said he had only taken a subsidiary part in the matter, but he made the commutator, and made it work, and that was of great importance.

The **President** (Dr. Glaisher) congratulated Mr. Glazebrook on the satisfactory nature of the report.

ON THE ELECTROSTATIC FORCE BETWEEN CONDUCTORS CONVEYING STEADY OR TRANSIENT CURRENTS.

By Dr. **Oliver Lodge**.

(*Presented to the A Section, September 9th*, 1890.)

AT the last meeting of the Physical Society this session, Mr. Boys described some attempts he had made to detect mechanical force between a pair of Hertz resonators delicately suspended and immersed in a region of electromagnetic waves.

The attempt, so far, had not been successful; but Mr. Boys, by attending to the energy manifested by Mr. Gregory's method, and by another method of his own, showed good reason why the force, if any, was just too small to be observed even with his extremely delicate appliances, and conjectured that a moderate increase in sensitiveness would be necessary in order to detect the effect.

Every one must have full confidence that if any such mechanical effect exists, Mr. Boys will show it us before long; but, in common with Prof. Fitzgerald, I feel provisionally and tentatively doubtful whether any mechanical effect really exists between electric pulses travelling along wires with the velocity of light. In a wire subject to electric stationary waves there are obvious electrostatic pulses at either end and electrokinetic pulses in the middle: but Mr. Boys had allowed for all that, and arranged that the opposing effects of ends and middle should conspire to assist each other in causing rotation. What I felt doubtful about was, whether even in infinite wires, wherein all complication by reflection and stationary waves was avoided, a pair of pulses travelling side by side, like a pair of humps (or a hump and a hollow) on a pair of parallel cords, would exert any force on each other. It is known that two charged bodies flying side by side with the velocity of light will exert no such effect (Mr. Heaviside has shown that this is equivalent to saying that two elements in the same wave-front exert no mechanical force on each other); but whether the same thing is true of two wire-conducted pulses has not, so far as I know, been examined by mathematicians.

If it should turn out that pulses at full speed have no effect, then two straight oscillators in similar phases should repel each other, by the electrostatic effect of the slackening and stationary pulses which are being reflected at the ends.

Such an action seems optically rather interesting. Maxwell predicted that a reflector or absorber would be repelled by light; though, as we know, the complication of the more vigorous molecular action of material surroundings prevented Mr. Crookes from detecting this precise effect. We know, however that it must exist; and the repulsive effects between alternating magnets and copper discs, detected by Faraday and recently made much of in an interesting manner by Prof. Elihu Thomson, are examples of this very thing. We can even say what the stress caused by full sunshine ought to be, viz., about 50 microbarads;* that is, the weight of half a milligramme per square metre; but it has not yet been experimentally observed. If Mr. Boys finds his effect, at least if he finds it in the form I suggest, as an overbalancing static repulsion, it will represent an action between two sources of light or between two similarly illuminated bodies.

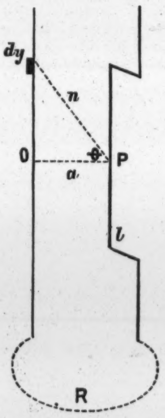
On the afternoon of the meeting of the Physical Society, by Mr. Boys's kindness, I made in a back room a hasty experiment on the pulses of a Leyden jar discharge, which was passed either in the same or in opposite directions through a pair of flexible parallel strips of aluminium foil, looked at through a microscope.

A fairly distinct effect was observed, its sign being, so far as one could tell, the sign of the electrokinetic effect; *i.e.*, attraction between currents in the same direction, repulsion (more easily observed, because, as it was arranged, nearly four times as strong) between opposing currents. Hence it would seem, so far as this crude observation goes, that pulses in wires do exert their electrodynamic effect. I expected, however, that, by suitably arranging matters, the electrostatic effect of the pulses could be made able to overpower their electro-magnetic effect. It is perhaps rather a barbarous plan to consider the two things separately; but until some one attacks the problem in a powerful manner I have been interested in groping at it, and accordingly make this communication.

First, consider the action of currents in general on each other, and find the ratio between their electrostatic and electrokinetic forces. So far as I know, the electrostatic force between two steady currents is usually overlooked.

No advantage in generality is gained by treating two separate circuits, a movable portion arranged near a fixed portion of one and the same circuit is sufficient.

Arrange a short length, l, at a distance, a, from a long parallel conductor; with a resistance, R, intervening between O and P, the middle opposite points of each; and through the whole send a current, C, up one and down the other.



Then the difference of potential between the two points is R C, or, with alternating currents, P C, where P is the impedance of the wire R; and if the capacity per unit length of the two conductors is called S_1, the linear density of charge on each is on the average $\lambda = S_1 R C$; a little more above O and a little less below it; but unless the distribution of potential differs greatly from a linear distribution, as when l is comparable to a wave-length, the mean value will serve.

The electrostatic attraction between the two conductors is

$$F = \int_0^l \int_{-\infty}^{+\infty} \frac{\lambda\, dy \,.\, \lambda' dy' \,.\, \cos\theta}{K\, r^2} = \int_0^l \int_{-\frac{1}{2}\pi}^{+\frac{1}{2}\pi} \frac{\lambda\, dy \,.\, \lambda' \cos\theta\, d\theta}{K\, a}$$

$$= \frac{2\lambda\lambda' l}{K\, a} = \frac{2\, l}{K\, a}(S_1 R C)^2 \qquad (1)$$

Unless one of the conductors is very long there is another term, which, however, it is unnecessary to write.

The electrokinetic repulsion between the same conductors is similarly

$$F' = \int\int \frac{\mu\, C\, dy\, C'\, dy' \cos\theta}{r^2} = \frac{2\mu l}{a} \,.\, C^2 \qquad (2)$$

Steady Currents.

Hence with steady currents the ratio of the static attraction to the magnetic repulsion is

$$\frac{F}{F'} = \frac{S_1^2 R^2}{\mu K}, \qquad (3)$$

which on every possible system of units is a pure number.

To get a notion of its value, suppose the wires to be round and of radius ρ; then

$$S_1 = K \Big/ 4 \log \frac{a}{\rho};$$

so, remembering that

$$\frac{1}{\mu K} = (\text{the velocity of light})^2 = \left(\frac{30 \text{ ohms}}{\mu}\right)^2,$$

we see that the above numerical ratio is

$$\frac{F}{F'} = \left\{\frac{\text{number of ohms in the wire } R}{120 \log \frac{a}{\rho}}\right\}^2 \qquad (3')$$

Suppose, for instance, the wires were 50 diameters apart, or $4 \log a/\rho = 18{\cdot}4$, the two forces would be equal, and just balance each other, if R was 552 ohms.

With any resistance greater than this the electrostatic force would have the advantage, and two opposite currents in the given wires would *attract*.

Alternating Currents.

If the current used is an alternating one, impedance must be inserted in (1) and (3) instead of resistance: no other change is necessary. Hence an impedance meter suggests itself. Send a current alternating with given frequency through the pair of conductors joined by the impedance to be measured, and either adjust S_1 until the electrostatic and electrodynamic forces balance, or estimate the outstanding force by a torsion arrangement. Supposing a balance could be got, the impedance of the intervening conductor, for the particular frequency applied, is

$$P = \frac{1}{S_1 \text{“}v\text{”}} = 60 \log \frac{a^2}{\rho\rho'} \text{ ohms.}$$

Leyden Jar Discharge.

Next proceed to consider the transient current of a Leyden jar discharge round the same circuit.

Let a jar of capacity S charged to potential V_0 be discharged round a circuit whose total resistance and inductance are R_0 and L_0 respectively. Then the current at any instant after the discharge has begun is

$$C = \frac{V_0}{p L_0} e^{-mt} \sin pt; \text{ where } m = \frac{R_0}{2 L_0}, \text{ and } m^2 + p^2 = \frac{1}{S L_0}.$$

The electrodynamic repulsion between the two wires previously considered, when the discharge occurs, is, therefore, applying (2), an impulse:—

$$\phi' = \frac{2\mu l}{a} \cdot \left(\frac{V_0}{p L_0}\right)^2 \int_0^\infty e^{-2mt} \,.\, \sin^2 pt \,.\, dt$$

$$= \frac{2\mu l}{a} \cdot \frac{\frac{1}{2} S V_0^2}{R_0}. \qquad (4)$$

To investigate the electrostatic attraction completely we should have to take into account the sinuous distribution of potential in space over the circuit; but, unless the waves are much shorter than usual, the ultimate effect on a short length will be very little different from the effect of a uniform potential alternating sinuously in time, the difference of potential at any instant between the fixed and movable wire being

$$V = P C,$$

where P is the impedance of the intervening portion of the circuit. Hence the electrostatic impulse is, by (1),

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* Langley's recent estimate, that a square centimetre fully exposed to sunshine receives 2·84 C.G.S. thermal units per minute, is equivalent to an energy of 67 ergs per cubic metre of sunshine, or 67 microbarads. (A "barad" means an erg per cubic centimetre, or a dyne per square centimetre.)

$$\phi = \frac{2\,l}{K\,a}\,S_1^2\,P^2\int_0^\infty C^2\,d\,t$$

$$= \frac{2\,l}{K\,a}\,.\,\frac{\frac{1}{2}\,S\,V_0^2}{R_0}\,.\,S_1^2\,P^2. \qquad (5)$$

And the ratio of the two impulses is

$$\frac{\phi}{\phi'} = \frac{S_1^2\,P^2}{\mu\,K}. \qquad (6)$$

Now $P^2 = p^2\,L^2 + R^2$, where $p^2 = \frac{1}{S\,L_0} - \left(\frac{R_0}{2\,L_0}\right)^2$.

So, noticing that $R/R_0 = L/L_0$ as nearly as we please,

$$P^2 = \frac{L}{L_0}\left(\frac{L}{S} + \frac{3}{4}\,R_0^2\right).$$

The second term is frequently negligible, though there is no difficulty in taking it into account if it is not; so the ratio of the impulses, at its least is

$$\frac{\phi}{\phi'} = \frac{S_1^2}{K^2}\cdot\frac{L}{L_0}\cdot\frac{L/\mu}{S/K}. \qquad (6')$$

The first of these three numerical factors depends merely on the shape of the acting conductors and their distance apart. The second is a proper fraction which may be made as near unity as we choose. The third involves a comparison between the electromagnetic measure of inductance of the wire included in the circuit, and the electrostatic measure of capacity of the discharged Leyden jar.

Taking as an example the same round wire conductor as before, with

$$S_1 = \frac{K}{4\log\frac{a}{\rho}} = \frac{K}{18{\cdot}4},\ \text{say},$$

and considering $\frac{L}{L_0}$ as $\left(\frac{18{\cdot}4}{20}\right)^2$ for instance, we perceive that the two impulses will be equal and just balance each other if the length representing L on the magnetic system of units be 400 times as great as the length representing S on the electrostatic system. Any wire longer than this gives attraction the advantage; any wire shorter than this favours repulsion.

Or, with different jars discharging round a given circuit, small jars will exhibit the electrostatic impulse, big ones the electrokinetic.

Illustrating numerically still further; a length of 30 metres of No. 16 copper wire opened out into a single large loop has a self-induction of 500 "metres" or 50 micro-secohms. Using this as the wire R between the two suspended conductors, the critical sized Leyden jar which should excite no force when discharged through them is about 1¼ "metres" or ·00014 microfarad; *i.e.*, smaller than the ordinary "pint" size.

With the help of an adjustable condenser, an instrument for measuring the L of well-insulated coils free from iron suggests itself here.

Ribbon Conductors.

If strips are used instead of round wires for the movable conductor, the electrostatic effect has an artificial advantage given it: for take a pair of similar strips, of length l, breadth b, and distance apart a, the force caused by a current C flowing through them with uniform intensity everywhere is easily calculated to be

$$\frac{4\,C^2\,l\,\mu}{a}\left(\frac{\alpha}{\tan\alpha} + \frac{\log\cos\alpha}{\tan^2\alpha}\right),$$

where α is an angle whose tangent is b/a.

The quantity in brackets has a maximum value ½ when $\alpha = 0$, *i.e.*, when the plates are far apart enough for their shape to be immaterial; and its value decreases steadily towards zero, viz., $\frac{1}{2}\,\pi\cot\alpha$, as α approaches 90°; the whole becoming ultimately $2\,\pi\,\mu\,C_1\,.\,cl$.

As for the electrostatic force between strips, I do not know how far we are justified in assuming uniform distribution of density, even if given uniform distribution of current; but at least when the plates are close together the force will not be very different from

$$2\,\pi\,.\,\frac{S\,V}{K\,A}\,.\,S\,V = \frac{2\,\pi\,l}{K\,b}\,.\,(S_1\,P\,C)^2;$$

the value of S_1 being $\frac{K\,b}{4\,\pi\,a}$.

So the ratio of the forces for large close plates is

$$\frac{K}{\mu}\,.\left(\frac{P\,b}{4\,\pi\,a}\right)^2 = \left(\frac{\text{No. of ohms in impedance of wire}}{120\,\pi\,a/b}\right)^2.$$

Hence with strips six times as broad as their distance apart the forces will balance for a steady current when the interposed wire is only 60 ohms resistance.

Measure of "v."

In applying an experimental observation of this kind to a determination of the product of the æther constants μ, K, (and it just strikes me that it is after all only a modification of the method by which Maxwell himself made one of the early determinations), it will be better to use round wires rather than strips, because linear dimensions then come in only under a logarithm, and moreover are such as can be measured with considerable accuracy without difficulty. Some of Mr. Boys's quartz-fibre and aluminium tube devices ought to permit the zero of force to be sharply got, and thus a good measure of "v" to be made.

We should have to observe very exactly the neutralisation of all force between the suspended and fixed conductors while a steady current was passing through them, with an interposed wire of known resistance, and then use the relation (3) or (3′) in the form

$$\mu\,K = S_1^2\,R^2,$$

or

$$\text{“}v\text{”} = \frac{S_1}{K}\,.\,\frac{R}{\mu} = \frac{\text{resistance of wire expressed as a velocity}}{4\log\frac{a}{\rho}}. \qquad (7)$$

If the acting conductors are set very near each other, a being still the distance between their centres, the denominator alters itself a little, becoming

$$2\log\frac{a^2 - 2\,\rho^2 + a\,\sqrt{(a^2 - 4\,\rho^2)}}{2\,\rho^2},$$

with an easy additional complication if it is convenient to make the sectional radii unequal.*

By filling the vessel containing the acting conductors with other insulating media, it is possible that the "v" for them could be directly measured.

Action of Moving Charges and Pulses.

So far I have not taken into account the sinuosity of distribution of Leyden jar discharges in space, nor the possibility of pulses passing the two portions of the circuit between which the force is being observed at different times or in different phases. It would seem as if a small assemblage of short-waved pulses sent round a long circuit might be prevented from exerting any mechanical action on each other if the adjacent parts of the circuit in which their action was to be observed were purposely separated by an intervening length of wire of many wave-lengths unsymmetrically introduced into the circuit. But before committing myself I should like to make a few experiments. Nevertheless I am tempted to go on a little further.

If, instead of considering pulses rushing along stationary wires, we consider charged wires moving along endways with the speed of light, Mr. Heaviside has attacked the general problem in the *Philosophical Magazine* for April, 1889. He there shows that between two planes perpendicular to a wire thus moving and moving with it at a distance apart equal to the length of the wire, the electrostatic intensity is

$$E = \frac{2\,\lambda}{K\,r},$$

and the magnetic intensity is

$$H = \frac{2\,\lambda\,v}{r},$$

where λ, the linear density, may be distributed anyhow on the wire. Outside these two planes the force is zero.

If the two intensities were to act, one on a stationary charge of any number of electrostatic units, the other on a stationary magnetic pole of the same number of magnetic units, the two forces would be equal. If they act on a wire conveying a steady current, and charged up to a certain linear density, the forces will be equal when the statical measure of density is equal to the magnetic measure of current, *i.e.*, when $C = v\,\gamma$; for then

$$E\,\lambda = H\,\mu\,C.$$

Lastly, if the two forces due to one bit of charged wire, moving in its own line with the speed of light, act on another similarly moving piece, the current equivalent to the second wire will be $v\,\lambda'$; and again there will be an equality between electrostatic and electrokinetic forces;

$$\frac{2\,\lambda}{K\,r}.\,\lambda' = \frac{2\,\lambda\,v}{r}\,.\,\mu\,\lambda'\,v.$$

Not by any different λ, or by any rearrangement of λ, can the balance be disturbed: only by a different v. If either wire moves with velocity less than that of light, the electrostatic force overpowers the other, but, so long as the full velocity is maintained, the density on either wire may have any value, positive or negative without disturbing the balance; and this is natural enough, when, as here, λ and C vary together; for if λ be zero or negative anywhere, C is also zero and negative, and the balance persists.

Now proceed to the case of alternating pulses travelling along parallel stationary wires. Their speed of travel is the speed of light, and though the distribution of both density and current is sinuous there is nothing in that disturbing to a balance; moreover, so long as the waves are freely progressive, λ and C still accompany each other exactly, and nothing but a balance will be observed in a closed circuit, however, the phases operating in the acting portions be altered, if the right proportion holds between the current and the potential, as already calculated.

But if by reflection at distant unjoined ends of an open circuit the pulses be turned from progressive into stationary waves, then localities can be found on the wires at which attraction or repulsion permanently occurs; for λ and c are no longer companions. the sinuous distribution of current lags a quarter period behind the sinuous distribution of charge. Hence at a given instant there will be places where the current force is a maximum and the static force zero; while at a quarter wave-length on either side the current force is zero and the static force a maximum. Halfway between these places only will the two forces be equal, but with alternate agreement and disagreement of sign. A readjustment of phase between the conductors will now make all the difference; a shift of a quarter wave-length changing from maximum to zero, and a shift of half a wave-length bringing about reversal of sign.

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* See Foster and Lodge, *Phil. Mag.* June, 1875, p. 456.

According to all this, therefore (if it be correct) it follows that the simple ideas on which Mr. Boys set to work are right after all, and that he will detect the forces in the way he expects.

Variation with Distance.

A few words as to the magnitude of the effect to be expected. Hertz has shown (see *Nature*, Vol. XXXIX., p. 404) that at a reasonable distance from a rectilinear oscillator, one or two wave lengths being practically sufficient, the electric force (or electromotive intensity) is perpendicular to the radius vector from middle of oscillator, and is of magnitude

$$E = \frac{Q\,l\,q^2}{K\,\rho}\,.\,\sin(q\,\rho - p\,t)\,.\,\sin\theta; \qquad (8)$$

where ρ and θ are the polar co-ordinates of the place, and $q = 2\pi/\lambda$.

Calling the length of the oscillator the axis, and the normal plane through its middle the equator, this means that the electric force is a maximum at the equator, diminishes towards the poles, and varies along any radius with the inverse distance from the centre.

At smaller distances the law is not so simple, but at any distance in the equatorial plane the electric oscillation is parallel to the oscillator, and of amplitude

$$\frac{Q\,l}{K\,r^3}\sqrt{(q^4 r^4 - q^2 r^2 + 1)},$$

showing that close to the oscillator the electric force varies as the inverse cube of the distance, at intermediate distances more slowly, while at a very few wave-lengths (practically one is sufficient) the first term under the root overpowers the others, and the ordinary law of the inverse distance holds good.

To get an idea of the magnitude of this intensity at any considerable distance from the axis, write $Q = S\,V$, where V_0 is measured by the length of spark employed at the oscillator, and write for q^2 its value $\frac{\mu\,K}{L\,S}$; then the amplitude of the electric force is

$$E = \frac{S\,V\,l\,.\,\mu\,K\,.\,\sin\theta}{K\,\rho\,.\,L\,S};$$

or, as $L = 2\,l\,\mu\left(\log\frac{4\,l}{d} - 1\right) = 2\,\mu\,l\,c$, say,

$$E = \frac{V\sin^2\theta}{2\,r\,c} \qquad (9)$$

Take as a numerical example any convenient oscillator, say, to avoid unnecessary repetition of specification, the small oscillator drawn to scale on page 54 of the *Philosophical Magazine* for July, 1889, which emits waves 1 metre long: let its constant $c = 4\frac{1}{2}$, and its spark be, as there quoted, 8 millimetres, so that V_0 is about 26,000 volts. Then the initial electric intensity at a distance of a couple of wave-lengths in the equator is

$$E_0 = \frac{26{,}000 \text{ volts}}{18 \text{ metres}}$$

$$= 14{\cdot}4 \text{ volts per centimetre.}$$

Putting, therefore, at this distance of 2 metres a parallel wire half a wave-length long as receiver, it utilises 50 centimetres of the above electromotive force, and gives a maximum sparking potential of 720 volts, which corresponds to a spark-gap of about a tenth of a millimetre between flat surfaces. This is an upper estimate, because time for a quarter-period's dissipation should be allowed, the result being multiplied by a dissipation factor *exp.* $\left(-\frac{\frac{1}{4}\lambda}{v\,S\,R}\right)$; where R is to be found as follows.

Energy of Radiation.

The mean energy of the radiation per unit volume is, as is well known (Maxwell, art. 793), $\frac{K\,E^2}{8\,\pi}$; which in the present case, abbreviating the characteristic factor, $\left(\log\frac{4\,l}{d} - 1\right)$ or its equivalent, to c, is,

$$\frac{K}{8\,\pi}\,.\,\frac{V^2\sin^2\theta}{4\,\rho^2\,c^2} \qquad 10)$$

The energy sent per second through the sphere of radius ρ with velocity "v," is

$$\int_0^{\pi} 2\,\pi\,\rho\sin\theta\,.\,\rho\,d\,\theta\,.\,\frac{K\,V^2\sin^2\theta}{32\,\pi\,\rho^2\,c^2}\,.\,v$$

$$= \frac{4}{3}\,.\,\frac{K\,v\,.V^2}{16\,c^2}$$

$$= \frac{V^2}{12\,\mu\,v\,c^2}. \qquad (11)$$

And this is the rate at which the oscillator radiates energy during its activity. Comparing (11) with (10) we see that the equatorial radiation exceeds the mean radiation in the proportion of 3 : 2.

The difference of potential V is not constant, but decreases logarithmically according to the law

$$V = V_0\,e^{-\frac{t}{S\,R}};$$

where R is a dissipation-coefficient of the dimension of resistance, and of value easily found, thus:—

Total energy radiated for every spark of the oscillator is

$$\int_0^{\infty} \frac{V_0^2\,e^{-\frac{2\,t}{S\,R}}}{12\,\mu\,v\,c^2}\,d\,t = \frac{\frac{1}{2}\,S\,V_0^2\,.\,R}{12\,\mu\,v\,c^2},$$

which must also equal $\frac{1}{2}\,S\,V_0^2$, the initial energy; hence

$$R = 12\,\mu\,v\,c^2 = 360\,c^2 \text{ ohms.}$$

Taking as a numerical example the same oscillator as above, with $c = 4\frac{1}{2}$ and $V = 88$ electrostatic units, all these values are easily estimated. For instance, the mean energy of the radiation per unit volume at any considerable distance r, say 2 metres, in the equator, is

$$\frac{K\,V^2}{32\,\pi\,c^4\,r^2} = \frac{88 \times 88}{25 \times 81\,r^2} = \frac{3{\cdot}8}{r^2} = \frac{3{\cdot}8}{4 \times 10^4} \text{ barads}$$

= 95 microbarads, at a distance of two metres.

This will cause a momentary pressure on a metallic surface normally exposed to it, of 95 microdynes per square centimetre, or a milligram weight per square metre; and is nearly twice as strong as full sunshine while it lasts.

At 1 metre distance, I need hardly say, the energy and pressure are four times as great.

The area of energy absorbed by a fine wire linear receiver may be estimated roughly by finding the closeness of a grid of parallel wires which would just not let any radiation pass through it. Suppose, for instance, that a grid with wires 10 centimetres apart satisfies this condition; then each wire mops up energy for a breadth of 5 centimetres on either side of itself. The heat generated in such a wire at each spark is

$$\frac{3}{2}\,.\,\frac{b\,l}{4\,\pi\,r^2}\,.\,\frac{1}{2}\,S\,V_0^2.$$

This, in the numerical case already taken, with $\frac{S}{K} = 1{\cdot}4$ centim. and $K\,V_0^2 = (88)^2$ dynes, gives, at a distance of 1 metre,

$$\frac{3 \times 500}{25 \times (100)^2} \times {\cdot}7 \times (88)^2 = 32\;5 \text{ ergs per spark};$$

which, repeated 100 times a second by a suitable contact-breaker, would yield 3,250 ergs per second, or 1 ordinary thermal unit every $3\frac{1}{3}$ hours.

The dissipation-factor, mentioned at the end of last section, is $e^{-\frac{100}{1{\cdot}4 \times 12 \times 81}}$.

Attempt at further detail.

To work out more completely what happens when one oscillator is used to excite another arranged parallel to it at an equatorial distance r, not near enough to re-act, I suppose we may consider the receiver as subjected to an impressed E.M.F. given by (8), and write down the equation to its current x at any instant,

$$\ddot{x} + 2\,\kappa\,\dot{x} + n^{2\prime}\,x = \frac{l'\,V_0}{2\,r\,c}\,e^{-m\,t}\sin(q\,r - p\,t), \qquad (12)$$

the solution of which is given (for instance) in Lord Rayleigh's "Sound," Vol. I., p. 62.

The heating of the receiver at each spark will be $\int_0^{\infty} R'\,\dot{x}^2\,d\,t$.

If there be two such receivers, far enough off each other not to encroach on each other's field, the current attraction between them will be proportional to $\dot{x}_1\,\dot{x}_2$, and the static repulsion to $x_1\,x_2$.

Calling the right-hand side of the above equation U, and writing $n'^2 - \kappa^2 = n^2$, the complete solution is

$$x = \frac{1}{n}\int_0^t e^{-\kappa(t-t')}\sin n\,(t - t')\,.\,U'\,d\,t'$$

$$+ \frac{x_0}{\cos}\,.\,e^{-\kappa t}\cos(n\,t - \gamma); \qquad (13)$$

where U' is the same function of t' that U is of t, and where

$$\tan \gamma = \frac{x_0}{n x_0} + \frac{\kappa}{n}.$$

The second term in the above, which expresses free vibrations in the receiver, may be made zero, because it contains the initial disturbance of the receiver as a factor; and the first term, which expresses forced vibrations, simplifies down to

$$x + \mathrm{C} = \frac{l'\mathrm{v}_0}{4nrc} \cdot e^{-mt}\left(\frac{\sin \alpha}{p-n}\cos(qr - pt + \alpha) - \frac{\sin \beta}{p+n}\cos(qr - pt + \beta)\right), \quad (14)$$

where $\tan \alpha = \frac{p - n}{\kappa - m}$, and $\tan \beta = \frac{p + n}{\kappa - m}$.

If there is anything like agreement between the natural periods of vibrator and resonator, the first of these two terms overpowers the other.

Another way of writing the solution is

$$x + \mathrm{C} = \frac{l'\,\mathrm{v}_0}{4\,r\,c\,n} \cdot \frac{\sin(\beta - \alpha)}{\kappa - m} e^{-mt} . \sin q\,r - p\,t \mp \alpha + \beta). \quad (15)$$

Appendix.

It is in accordance with theory to assert that the action of two given magnets on each other varies inversely with the permeability of the medium; that the action of two currents on each other varies directly as the permeability of the medium; and that the action of a current on a given magnet is independent of the properties of the medium.

To avoid misunderstanding, it must be perceived that the statement refers to a given magnet, not to a magnet of numerically specified strength, because about that there would be some ambiguity according to the medium in which it was measured.

Similarly, the static action between two charges is inversely as the dielectric constant of the medium; the action between a given charge moving at the approximate light speed and a given magnet is independent of the medium, except in so far as its properties affect the velocity of light; while the dynamic action between two given charges moving together at the light speed is proportional to the permeability.

It may be as well to have direct experimental verification for some of these things.

LEGAL.

Watt v. Maxim-Weston Company, Limited—Maxim-Weston Company, Limited v. Watt.—On Wednesday, before Mr Justice Vaughan Williams (vacation judge), sitting in the Chancery Division of the High Court of Justice, Mr. E. Morten applied *ex parte* in the above actions, which would shortly come before Mr. Justice North for trial, for an order for the examination of a witness before a special examiner. The actions involved a great many issues, one important thing being to unravel the dealings which had taken place in the shares of the company at the instance of Mr. Watt, the chairman of the company. For this purpose it would be necessary to have the evidence of the stockbroker who carried out the transactions on the Stock Exchange for Mr. Watt. Information had been just received that Mr. Barnard, the stockbroker in question, was about to depart for America in search of sport, which was likely to keep him there for the next six months. That being so, it was desired to take the examination early next week. In the case of Bidder v. Brydges, the Court had held that such an order would be made where necessary for the purposes of justice.

His LORDSHIP said he was somewhat loth to make the order *ex parte*, but he would do so upon conditions. It was quite plain the examination could not be conducted effectively unless the other side had notice and the opportunity of being present. The order would go, but would contain upon its face the condition that notice should forthwith be given to the other side, and that they should be at liberty to apply to discharge the order.

Woodhouse and Rawson, Limited.—A motion for the removal of the liquidators of this company, for the appointment of others in their place, and to restrain further dealing with the assets, was in the list for hearing, but Mr. Baker stated that, by consent, it had been arranged that the motion should be withdrawn from the paper, no order being made upon it.

His LORDSHIP acceded to the application.

The City Lighting.—The City Commissioners of Sewers, at the instance of the Streets Committee, on Tuesday, resolved to invite tenders for lighting by electricity the western districts of the City on similar conditions to those arranged for the east and central districts, but intimating that should any deviation from such conditions favourable to the Commissioners be desired by the companies tendering, such deviation must be specifically set forth.

NOTES.

Electric Lighting in Hampshire and Sussex.—The electric light is making considerable progress in Hampshire and Sussex. At Portsmouth, the special committee which has been appointed to consider the steps to be taken to introduce the light into the borough, are about to retain the services of an eminent electrician. The Winchester Council have determined to send a deputation to Fareham, where the electric light is in full operation. At Lewes last week a public meeting of the ratepayers was convened by the mayor for the purpose of considering the question of street lighting. A long discussion ensued, and eventually it was determined to adjourn the matter for a fortnight.

Electric Lighting in Pemberton.—The Local Board of Pemberton, in Lancashire, are just now having a portion of their district lighted by electricity by way of experiment; and it is understood that if the experiment—which will extend over two months—is of a satisfactory character, this means of illumination will be adopted in substitution for gas. Messrs. Mercier and Corlett, of Wigan, have put down the plant for this experiment. Lighting commences at dusk and continues until 10 o'clock.

Electric Lighting in Nelson.—The Gas Committee of the Nelson Corporation have under consideration a scheme for the lighting of the town by electricity instead of gas as at present.

Lighting at Northampton.—The central station of the Northampton Electric Light and Power Company, Limited, is being erected by Messrs. Crompton and Co., Limited, who are also doing the wiring of the hotels, houses, shops, &c., to be lighted. Mains are already laid in several of the streets and current will shortly be available.

The Electric Light at Exeter.—The Exeter City Council held a meeting on Monday to consider an application from the Electric Light Company and a recommendation from the special committee on electric lighting that steps should be taken to obtain a provisional order for the Council. Mr. Alderman Andrew proposed: "That, inasmuch as any monopoly of the supply of electric light was rendered impossible by the Acts of 1882 and 1888, which also safeguard the interests of the citizens in other directions, it is not desirable that the Council should take steps to obtain a provisional order until it has ascertained what arrangements can be made with the existing Electric Light Company for the optional purchase by the Council of their works at shorter specified periods than 42 years." He reiterated a statement which he had previously made, that if the Authority obtained the necessary powers from the Board of Trade it would cost them £30,000. Mr. Pope seconded the amendment, which, after a discussion, was adopted by 28 votes to 13. A small committee was appointed to confer with the Electric Light Company and go into all matters of detail.

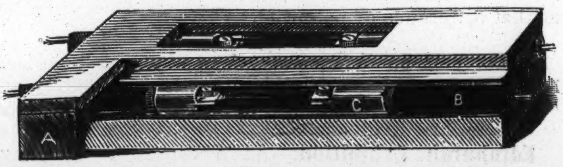
Electric Lighting in Chelsea.—The figures given by the surveyor in the vestry's annual report and published by us are rather ancient. The houses taking current have increased to 180, and, including those in South Kensington, represent 17,300 candle-power.

Electric Lighting in Leeds.—At a meeting of the Leeds County Council, on Monday, it was decided to leave the lighting of the Borough to private enterprise.

Exhibition at Palermo.—It is announced that a national exhibition will be held at Palermo during the coming year. The committee has determined to make the electrical portion of the exhibits a feature of much greater importance than was the case in the exhibitions at Turin and Milan.

The Proposed Spanish Cables.—The issue of *Industries* for the 3rd October contains the following note with regard to the telegraph cables to the African coast:—"Two tenders have been sent in to the Spanish Government for the laying of the cables from the coast of Spain to the African possessions in Morocco. One of the tenders is from the India-Rubber, Gutta Percha, and Telegraph Company, London, and the other from the Spanish National Company. Neither of the tenders agreed strictly with the bases that were required by the Government, and it seems likely that they will be rejected. The administration would have preferred to receive a tender from Messrs. Siemens, but this firm would not have agreed to such risky conditions as the Government demanded. The fact is that the cables to the other side of the Strait have a bad history." Our contemporary would have added considerably to the interest with which this note will be received had some authority for the last paragraph been given. The history of cables across the Strait would be a valuable addition to the records of submarine telegraphy.

The Champion Cut-out.—Under this name, Mr. J. Torr Todman is making a cut-out which can be placed in the ordinary wood casing which covers the cable, thus avoiding the necessity for cut-outs projecting from the walls. In the figure, A is the wood casing, B the cable, C the cut-out, consisting of two brass ends in which the cable is soldered. These two ends are joined by a strip of vulcanised fibre, and the fuse wire is fixed under the two screws shown. The fuse and connection is covered by a glass tube which slides along the cable when it is necessary to renew the fuse.



Recent Interruptions and Repairs to Submarine Cables and Land Lines:—

	Interrupted.	Repaired.
Cable:—Jamaica—Colon	16 July, 1890,	4 Sept., 1890.
Amoy—Shanghai	21 „ „	3 Aug., „
Buenaventura—Santa Elena	30 Aug. „	7 Sept. „
Suez—Suakim	12 Sept. „	13 „ „
Suakim—Perim	12 „ „	Still interrupted.
Land Line:—Buenaventura	10 Sept. „	13 Sep., 1890.
Moulmein—Bangkok	14 „ „	16 Sept. „

The Proposed Electric Tramways in Glasgow.—On Monday, September 29th, a deputation from the Glasgow Corporation, consisting of Bailie Paton (convener of general committee), Bailie Wallace (sub-convener of general committee), Bailie McFarlane, John Ure, Dean of Guild, and ex-Lord Provost, Councillor Colquhoun, and Mr. David Rankine, engineer, Glasgow Corporation Tramways, visited the General Electric Power and Traction Company's electric cars and installation on the Barking Road section of the North Metropolitan Tramways Company's system. The deputation were met by Messrs. Fuller and Macpherson, directors of the Electric Power Company, and by several of its leading officials. Having made a minute inspection of the many points of interest in the working of the cars, the corporation authorities expressed themselves as greatly pleased with all they had seen. The *raison d'etre* of the visit was, that the Glasgow Corporation have it in view to take into their own hands, at the expiration of the present concession, the entire Glasgow tramway service, and equipping the same with accumulator cars. On the following day the deputation visited the installation of the Central Birmingham Tramway Company.

Another Fatal Shock.—A telegram from New York, dated October 5th, states that a man was killed in New Orleans the preceding day through coming in contact with an electric light wire.

Account of a Cable Expedition.—The October number of *Scribner's Magazine* contains an account, written by Mr. Herbert Webb, of the laying of the cables connecting Spain with the Canary Islands. It was scarcely necessary to disguise the names of the vessels employed, since the names of the islands, to which the cables were laid, are given. This, however, is but a minor consideration, and in no way detracts from the merits of the article in question. Some of the difficulties met with in cable work are well described, and we may congratulate Mr. H. Webb on having written a popular account of some of the incidents connected with submarine telegraphy. The article is sufficiently well illustrated.

The Advantages of Technical Education.—The students of the Glasgow and West of Scotland Technical College appear to be doing well, especially in the engineering classes under Prof. A. Jamieson. Mr. James Raeburn, who attended the electrical engineering laboratory, has been despatched to St. Petersburg to settle details about the electric lighting of Odessa Harbour, the Russian Government having approved of his plans prepared for the Thomson-Houston Company, who are giving him £500 per annum. Mr. Arthur H. Allen, who gained first-class honours in both electricity and electric lighting last session, has entered the service of Messrs. Holmes and Company, of Newcastle; and Mr. Auchinachie, from Keith, has been given a good appointment with the well-known firm of Messrs. Siemens Brothers & Co., of London and Charlton.

O. S. A. Annual Dinner.—The sixth annual dinner of the Old Students' Association of the City Guilds of London Institute will be held at the Holborn Restaurant on Friday, October 17th, 1890, at 7 p.m. Tickets, price 4s. 6d. each, may be obtained from the secretary, 14, Garfield Road, Lavender Hill. Mr. W. B. Esson is the president of the Association for the ensuing session.

The Postmaster-General and the Case of Senior Telegraphists.—The following notice was posted in the Central Telegraph Department on Saturday last: "In continuation of the notice of the 14th July, the Postmaster-General desires to notify that, with the consent of the Lords of the Treasury, he has converted 43 of the existing senior telegraphists appointments on the male staff into a new body of second class assistant superintendents on a scale of £200, rising, by £10 annually, to £260. The minimum of the senior class of telegraphists will be £160 per annum." Twenty corresponding appointments will be made on the female staff. Curiously enough, these new appointments are dated Sunday, October 5th, and this very unusual circumstance has given rise to much speculation and conjecture.

The School of Electrical Engineering and Submarine Telegraphy.—As the result of the examinations recently held at the above school, we are informed that the following gentlemen have now obtained the Vellum Certificate of the school:—(*a*) In electric lighting and power transmission—Messrs. Claypoole, Garré, Gillies, Lawrence, Phillips, Roussel and Waring. The examinations in these subjects were conducted by Mr. Gisbert Kapp, and included a *vivâ voce* and practical examination. (*b*) In telegraphy and telephony—Messrs. Lawrence (above named) and Salmony. This examination was conducted by Mr. H. R. Kempe.

Movements of Cable Ships.—On the morning of Wednesday, October 8th, the s.s. *Silvertown* left the Silvertown Company's works, *en route* for the West Coast of America, to lay direct cables between Lima, Yquique, and Valparaiso.

H.M. telegraph ship *Monarch* sailed for the Irish Channel to repair one of the Post-office cables.

The s.s. *John Pender* left the river for, we are informed, the Red Sea, to relieve the cable steamer at present stationed there.

The Manchester Association of Engineers.—We notice in the syllabus of the 1890-91 season of the Manchester Association of Engineers that on January 24th next, Mr. A. B. Blackburne, assistant manager to Messrs. Mather and Platt's electrical department, is announced to read a paper on "Dynamos: the Consideration of the Chief features which Regulate their Application." We hope that Mr. Blackburne's latest experiences will enable him to put before his audience something new; in any case, his discourse is certain to prove interesting.

Anticosti Cable.—Messrs. W. T. Henley's Telegraph Works Company, Limited, write to us as follows:—"Referring to the paragraph under this heading in your "Notes" in the issue of the 3rd inst., we beg to inform you that this cable was made by us, the core being composed of our patent ozokerited vulcanised India-rubber, of which the Canadian Government have had considerable experience for some years past."

A Gallant Deed.—IN the REVIEW for September 19th, we chronicled the death of lineman Kepp, in New York, but there was an incident connected with this matter which has only just come to our notice through the columns of *Modern Light and Heat*, and which we have much pleasure in bringing before our readers. Our contemporary says:—"The electric lineman must beware of the live wire. If he is possessed of ordinary intelligence and presence of mind, and is thoroughly instructed in the duties and requirements of his calling, as every lineman should be, any accident which may befall him must be the result of his own negligence or hardihood. The death of lineman Kepp, and the gallant but too late rescue of the suffering man by Mr. Charles Phipps, of the Brush Company, illustrate this. Had the unfortunate lineman taken the ordinary precaution of using rubber gloves, he would have been alive to-day. Mr. Phipps's heroic act was fraught with much greater danger than that which menaced the lineman. He was coming out of the theatre in evening dress, and with rare presence of mind took in the whole situation at a glance. He had no rubber gloves, but he improvised a substitute with rubber coats borrowed from hackmen. Thus protected, he climbed the pole and cut the wire across which the lineman hung, after which he lowered the man into the arms of those who were waiting and watching below. Although Mr. Phipps made light of his brave action, those who saw it were more appreciative, and we believe that the gold medal of the Humane Society has been awarded to many not more deserving than the noble-hearted electrician."

Opening for Electric Traction.—Colonel C. M. Davidson, the chairman of the Hawaiian Tramways Company, stated at the meeting of the company last week that the "board were doing their best to keep down the expenses of the company, and with that view they were considering the advisability of running their tramway by electricity." English traction companies should attend to this.

The National Telephone Company.—We hear that the directors of the National Telephone Company, Limited, have decided to reduce their rates of £15 to £10 per annum, and that they are further considering the question of giving special advantages to their subscribers for trunk line service.

Dublin City Lighting.—The time for receiving tenders has been extended to the 30th October.

Killarney in the Running.—The Town Commissioners, after various flights of oratory, have again settled on the earth, and will apply for a provisional order in a reasonable manner.

Electric Light at Gravesend.—After many discussions the Town Council has resolved to apply for a provisional order.

Electric Traction.—At the usual meeting of the Oswaldtwistle (Lancashire) Local Board, on Monday, consent was given to Mr. Chadwick, C.E., constructing an electric tramway through that township to Accrington on satisfactory terms being arranged.

Personal.—Last week the electrical engineering pupils of Messrs. Immisch & Co., Kentish Town, presented a piece of silver plate, as a token of their esteem, to Mr. Charles Francis Quicke, late chief engineer and works manager, on his relinquishing that post, after eight years' connection with the firm. The workmen and staff also presented, on their own behalf, a massive silver spirit case and an inlaid cabinet.

Mr. G. Jones, electrical engineer at Chatham Dockyard, has been ordered to proceed to the works of the Naval Construction and Armament Company, Barrow-in-Furness, to assist Mr. Apsey, who recently proceeded from this yard to superintend the construction of the electric light apparatus which is being manufactured for vessels of the Royal Navy.

Electric Light Accidents.—A correspondent of the *Times* says an engineer in the electric light works at Waltham, in Massachusetts, last Thursday received an electric shock of 1,500 volts. His hands were badly burnt, but his injuries were otherwise not serious. Although he was, perhaps, working a 1,500-volt circuit, it does not follow that a current passed through him at that difference of potential.

A Correction.—A correspondent says our note last week, on "A Telegraph Superintendent Killed," was exaggerated; the man is still dead.

Edinburgh Exhibition.—At a committee meeting held last week in the City of London, it was resolved to consider the exhibition a success. Over three million people have passed the turnstiles, a fact which is probably due to the near vicinity of the Forth Bridge.

The Revolution in Copper.—On Thursday, the 25th September, Dr. John Hopkinson paid a visit to the works of Elmore's Patent Copper Depositing Company, at Leeds. His time was limited, so his report simply states that he had an opportunity of observing the effect of the burnishing tool upon the deposited copper which, under its influence, exhibited a beautifully smooth surface. He also confirms his previously expressed opinion that on a large scale the Elmore process of depositing should not exceed £5 a ton or ½d. per lb., and he returned well satisfied with what he saw. A report from Dr. Hopkinson, or any other qualified expert, giving a comparison of the actual cost of the Elmore and other processes for producing copper tubes would have been to the point, and have put us in possession of hard facts instead of estimated data with which we have hitherto had to content ourselves.

The Channel Telephone Cable.—We understand that Messrs. Siemens Bros. & Co. have secured the contract for manufacturing the 4-cored cable to be used for telephoning across the Channel.

Woodhouse and Rawson United, Limited.—The report and balance sheet of this company is before our readers, and the meeting to discuss the same takes place to-day. It would, of course, be very interesting to know how the gross profit of nearly £100,000 was made, how much from trading, and how much from company promoting. The shareholders, however, will doubtless be content with their 15 per cent., and we sincerely trust that so good a dividend will be always forthcoming.

Edinburgh and the Electric Light.—At a meeting of the Edinburgh Town Council on Tuesday, it was resolved, on the motion of the Lord Provost, to make application to the Board of Trade for a provisional order.

The Nicaragua Canal and the Telegraph.—In connection with the works on the Nicaragua Canal, which are stated to be progressing most favourably, we learn that a telegraph line has been completed between Greytown and the Lake of Nicaragua, where a junction is made with the telegraph lines to the Pacific Coast. We therefore presume that telegraphic communication is now established between Greytown and the United States *viâ* the Central and South American Company's cables which touch at San Juan del Sur, a port on the Nicaraguan coast, and connected by Government lines with the principal towns in that Republic.

Berliner's Gramophone.—Several gramophones of this make have, during the past three weeks, been shown in operation at 11, Queen Victoria Street, E.C. It is not unlikely that we may hear more of this invention shortly from a company point of view.

Electric Railway Experiments.—Some experiments have been made with a railway waggon fitted with motors and accumulators, on the local railway Hildburghausen-Heldberg-Friedrichshall, in Bavaria. The line is about 19 miles long, and the waggon is said to have worked successfully. This is the greatest test with electric traction in Germany. The experiments were made by the builder of the railway, Mr. Hostmann and two other engineers, one being from the Oerlikon Engineering Works.

The Report of the Postmaster-General.—The report of the Postmaster-General, issued last week, shows a great increase of business. Telegraphic money orders issued during the month of March amount to £6,262. In the course of the year 263 post-offices and 58 railway offices were opened for telegraphic business, making the total number of such offices open on the 31st March 5,673 and 1,679 respectively. The total number of telegrams dealt with was 62,403,399, as compared with 57,765,347 in the previous year.

NEW COMPANIES REGISTERED.

Leeds and London Electrical Engineering Company, Limited.—Capital £100,000, divided into 250 founders' shares, 9,750 non-cumulative £7 per cent. preference shares, and 10,000 ordinary shares of £5 each. Objects: To form centres in the United Kingdom and elsewhere at which electrical energy may be generated and accumulated, and from which the same may be distributed for public and private lighting of every description, or for supplying motive power or heat, and to enter into contracts for such purposes. To acquire the right to manufacture and put up telephones, telegraphs, electric bells, phonographs, and all other electrical apparatus now known or hereafter to be invented. To manufacture lightning conductors, electrical generators, motors, cables, accumulators, lamps, and fittings of all kinds. Signatories (with 1 share each): H. Linklater, 5, Benthal Road, N.; T. B. Arundell, 1, Devonshire Street, Portland Place; P. H. Clark, 51, Norroy Road, Putney; James Whitehead (electrical engineer), Heycot, Crouch End, N.; J. A. Roxburgh, 77, Queen's Road, Finsbury Park; J. Kerby Chambers (electrical engineer), 10, Richmond Villas, Holloway; J. W. S. Hawes, 25, Colebrooke Row, N. The signatories are to appoint the first directors; qualification, £500 in shares; remuneration, one-tenth of the net profits after payment of 7 per cent. dividend on preference and ordinary shares, provided that the maximum remuneration be £1,500 per annum. Registered 2nd inst. by Wilson & Co., 1, Copthall Buildings.

Electro-Metallurgical Company, Limited.—Capital £2,500, in £5 shares. Objects: To acquire the business of electro-metallurgists, platers and depositors on metals, carried on by the Electro-Metallurgical Company at 23, Newhall-street, Birmingham, and the business of electro-platers carried on by the Victoria Plating Company at 9 and 10, Sherborne Road, Balsall Heath, Birmingham. Signatories (with 1 share each): *Alfred Smallwood, *Alfred Gough, *H. Fenney, Wm. Ralph Bradley, J. J. Bedney Arter, J. H. Fenney, E. G. Walters, all of Birmingham. The signatories denoted by an asterisk are the first directors. Registered 3rd inst. by T. H. Philpots, 89, Chancery Lane, agent for Alfred Gough, 120, Edmund-street, Birmingham.

Buller's, Limited.—Capital £200,000, in £10 shares. Objects: To acquire the business and liabilities of Buller, Jobson & Co., Limited (in voluntary liquidation), engineers and contractors. To manufacture and produce electrical plant, and to supply electric and other forms of power and energy. Signatories (with 1 share each): *E. W. Buller, 49, Charlotte Road, Birmingham; *H. C. Jobson, Kidderminster; E. J. Chambers, Dudley; W. Greenhill, Dudley; E. P. Jobson, Dudley; A. T. Buller, Penrith; J. T. Harris, Stone, Staffordshire. The first two signatories are appointed directors; qualification, 100 shares. Registered 6th inst. by Waterlow Brothers and Layton, Limited, agents for Smith, Pinsent and Co., of Birmingham.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Patent Lithographic Zinc Plate Company, Limited.—The statutory return of this company, made up to the 20th August, was filed 6th September. The nominal capital is £10,000 in £5 shares; 700 shares are taken up, 200 being considered fully paid. Upon 500 shares £3 per share has been called and paid. Registered office, India Chambers, Queen's Dock Side, Hull.

J. A. Egestorff and Company, Limited (manufacturers of ultramarine and colours and electrical engineers).—The statutory return of this company, made up to the 29th August, was filed September 4th. The nominal capital is £10,000 in £5 shares; 1,290 shares have been taken up, 400 being considered fully paid. Upon 890 shares, £2 10s. per share has been called, the calls paid amounting to £1,509 10s., and unpaid to £715 10s. Registered office, Backbarrow, near Ulverston.

Buller, Jobson and Company, Limited.—At an extraordinary general meeting of the members of this company, held at the Great Western Hotel, Birmingham, on 16th ult., it was resolved to wind up voluntarily, the liquidator, Mr. W. Newton Fisher, of Waterloo Street, Birmingham, chartered accountant, being authorised to enter into an agreement with a new company to be called Buller's, Limited, for the transfer to that company of the assets and liabilities of this company. These resolutions were confirmed on the 2nd inst. and were duly filed on the 3rd inst.

The last return of the company is made up to the 10th February; the nominal capital at that date was £108,100 divided into 5,405 "A" and 900 "B" shares of £20 each. 4,505 "A" and 900 "B" shares have been taken up and the full amount has been called thereupon. Upon 4,497 "A" and 900 "B" shares the full amount is considered as paid up. The calls paid amount to £160. At a meeting of the company, held on the 7th March, the capital of the company was increased by the sum of £50,000, divided into 2,500 first preference shares of £20 each, carrying a cumulative dividend of 6 per cent per annum.

Kent Patent Arc Lamp Company, Limited.—The subscribers to this company have appointed as directors of the company Mr. Herman Stanberg, of 45, High Street, Borough, S.E., and Richard Dyson, of 15, Australian Avenue, E.C. The registered office of the company is now situated at 17, Holborn Viaduct. Secretary, Mr. Arthur Salter.

Baxter's, Limited (civil, marine and electrical engineers).—The statutory return of this company, made up to the 29th July, was filed 23rd August. The nominal capital is £30,000, divided into 1,000 preference and 5,000 ordinary shares of £5 each. 14 ordinary shares are taken up, and £4 has been called and paid thereon, the calls paid amounting to £56. Registered office, Sandiacre, Derby.

Peru Telephone Company, Limited.—The registered office of this company is now situate at 42, Old Broad Street, E.C.

Ecuador Telephone Company, Limited.—The registered office of this company is now situate at 42, Old Broad Street, E.C.

CITY NOTES, REPORTS, MEETINGS, &c.

Woodhouse and Rawson United, Limited.

THE annual report of the directors to be laid before the meeting at Winchester House to-day (Friday), the 10th inst., states:—Of the original capital all the ordinary and preference shares have now been issued. Of the ordinary shares, one-half of their value remains uncalled. The premiums from the second issue, amounting to £4,050 5s. have been placed to a reserve fund. From the balance sheet it will be seen that after payment of all expenses and writing off £7,421 16s. 9d. in reduction of the sum standing to patent account, the balance to the credit of the company amounts to £61,085 1s. 9d. Out of this sum the directors propose to pay a dividend at the rate of 15 per cent. per annum on the ordinary shares and of 8 per cent. per annum on the preference shares, which, together with the interim dividend for the half-year already paid at these rates, amounts to £18,749 6s. 6d. Of the balance, amounting to £42,335 15s. 3d., the directors propose to place to reserve £25,000, of which £10,000 will be set aside to a goodwill reserve fund, and £15,000 to a general reserve fund, and to apply £1,000 to the formation of an *employés* pension fund, leaving £16,335 15s. 3d. to be carried forward to next year's account. The directors do not propose to increase the dividend anticipated in the prospectus, as the prudence of building up reserve funds of a considerable amount will be evident to the shareholders.

The directors think it well on this occasion to give more information than is usually contained in an annual report, in order to enable the shareholders to realise the scope and extent of the operations in which the company is engaged. Their efforts during the past year have been directed to consolidating and extending the several branches of business which have been taken over by the company. These are of a very comprehensive character, and include:—

1. The manufacture of all articles connected with electricity and engineering, so far as they come reasonably within the technical and financial resources of the company.
2. The supply of all articles connected with electricity and electrical engineering.
3. The execution of all works of installation coming within the province of electrical engineers and contractors.
4. The testing and proving of new patents and inventions connected with electrical and engineering science, and their introduction to the public, either by arrangements for working such inventions by this company or by assisting the owners in forming separate companies for working them.

The experience of the past year leaves no doubt that great services may be rendered to the shareholders and to the public by developing this latter branch of the business, with prudence and energy; and the knowledge acquired from an extensive range of manufactures, and a thorough acquaintance with the demand and channels of supply of electrical plant and apparatus, place this company in an exceptional position to invite and secure the confidence of inventors, and to assist them in bringing their inventions before the public. With this object it is necessary to command the ready means of practically testing every kind of electrical and mechanical invention which may be offered, and to maintain an extensive business and correspondence in all parts of the world.

The following are the factories owned by the company and the character of the work done:—

a. West Kensington Hall Works, Hammersmith Road, W. These works, over an acre in extent, are the company's freehold. Here are manufactured light goods, such as switches, lamps, measuring and other electrical instruments, primary and secondary batteries, and every class of small automatic machinery. Here also is carried on the electro-plating business and manufacture of plating plant. At these works most processes offered to the company are tested, and only when they have thoroughly passed the examination of the company's experts is the purchase or introduction to the public entertained. At the present moment four important electrical inventions of exceptional merit are undergoing the process of final testing.

b. Union Foundry, Kidsgrove, near Crewe. These works, which are also freehold, have been recently acquired on advantageous terms, and are well situated in the heart of the coal and iron district, having both a railway siding and a canal adjoining. They are fitted up with every class of heavy machinery to enable the company to construct engines and boilers of almost any size or power, water and gas works plant, steam and hydraulic cranes, tanks, pumps, large dynamos and other heavy machinery, whilst further special plant is now being erected to keep abreast of recent improvements.

c. Cornbrook Telegraph Works, Manchester. These works are leasehold, and are fully engaged in the manufacture of telegraphic instruments; there are also manufactured small dynamos and motors, as well as light lathes and drilling, shaping, milling and screwing machines, specially designed for electrical work. Practically the whole of the contracts for telegraphic instruments, &c., for the London and North Western Railway for a period of two years, together with contracts for the Caledonian and Great Eastern Railway Companies, have been placed with the company at these works.

d. The supply department is rapidly increasing its turnover. Its catalogue of electrical goods and appliances connected therewith is recognised as the most complete and comprehensive of its kind, and forms a standard text book in the trade. The acquisition of the new warehouse, with entrance at 30, Cannon Street, and more recently of the lease of the neighbouring premises at 34, Cannon Street, and 84, Queen Victoria Street, enables the company to keep in hand and exhibit an extensive stock of nearly every kind of electrical apparatus and fittings.

e. The installation department has carried out a large number of important contracts. Among others, the lighting of the palace at Mysore, India, by electricity has been satisfactorily and profitably finished; and the Sociedad Española del Electricidad, in Barcelona, has placed the whole of their arrangements for improving and extending the lighting of that city by electricity in the hands of this company.

f. At Bradford the company have a branch establishment, with show room and warehouse, which provides for installations and the supply of electrical goods in the North of England. The company has been specially appointed contractors to the local authorities in that town in connection with their central electric lighting station.

g. An electric bell and signalling business is conducted at 2, Gray's Inn Road, under the management of the Messrs. Jensen, whose well-known patents this company has acquired.

h. The company has also acquired the electric and steam launch business of Mr. Sargeant, carried on at Chiswick.

Branch offices have been opened during the year in Sydney, Melbourne, Johannesburg, and Valparaiso, besides additional agencies in various other foreign countries. In the early part of the present year the directors disposed of a portion of their premises at West Kensington to the Kensington Co-operative Stores, Limited, a new company, which obtained the support of this company because it afforded an opportunity of disposing, upon advantageous terms, of a portion of its buildings unsuitable for manufacturing purposes, and increased the value of the remainder of the property. A second issue of shares of the Kensington stores has lately been made at a large premium, and was applied for two and a half times over. The directors have, in addition, been instrumental in forming the International Okonite Company, for the working throughout the world of the patents for that valuable insulating material. The company, whose shares have been entirely allotted, has an established business in America of a profitable and rapidly increasing character, and owns works also at Manchester, from which it will supply the okonite wire required in Great Britain. The yield of both the American and English works during the current year has largely increased, and a profitable return may be looked for. This report would not be complete without an illusion to the success that has attended the introduction by Woodhouse and Rawson, Limited, of the now well-known Elmore process for manufacturing copper articles by electro-deposition at a great saving of cost, and of unique quality. Since the expiration of the financial year ending on the 30th June, 1890, this company has introduced Elmore's French Patent Copper Depositing Company with very marked success; 66,750 shares were offered for subscription, and over 250,000 shares were applied for. The official quotation of the shares of this company in the Stock Exchange list is now before the committee. Owing to the delay in the winding-up of the vendor companies, mainly caused by the protracted arbitration in which one of them was engaged at the time of purchase, a final settlement with them had not been effected before the close of the first financial year of this company. These difficulties have since been removed, and the directors daily expect to have the quotation granted. The sum of £75,000 which, as stated in the prospectus, Woodhouse and Rawson, Limited, was to lodge with this company as a guarantee fund for the payment of a minimum dividend of 15 per cent. per annum for the first three years, has been duly received.

The shareholders will doubtless approve of the formation of an *employés* pension fund, which will tend to the retention of those employed by the company, by requiting faithful services when age, failing health, or other causes necessitate their temporary or permanent withdrawal from the company's employ. The amount proposed to be placed to the credit of this fund, though comparatively small for the purpose intended, will form a nucleus to which in future, as the company's success is consolidated, larger sums may be allocated. A resolution to give effect to this proposal will be submitted to the meeting. The directors feel that the shareholders owe a great deal to the various members of the staff for devoted services rendered, regardless of personal comfort and hours of labour, and especially to the managing director, Mr. F. L. Rawson, to whose zeal, enterprise and judgment the results obtained in this the first year of the company's operations are mainly due. By the articles of association two directors retire. The two who retire are Lord Aberdare and Sir Rawson W. Rawson; the latter, being eligible, offers himself for re-election; the former from impaired health and enforced absence from London, does not offer himself for re-election. In his place the directors propose, with the approval of the shareholders, to elect the Right Hon. Sir Edward Thornton, G.C.B. The auditors, Messrs. Pixley and Co., retire according to the articles, and offer themselves for re-election. In conclusion the directors congratulate the shareholders on the position and prospects of the company.

The International Okonite Company, Limited.

MR. SAMUEL POPE, Q.C., presided at the statutory meeting held at the Cannon Street Hotel yesterday, and after explaining the object of statutory meetings, went on to say that the company's articles of association provided that the first general meeting should be held within the statutory period of four months. The board, therefore, thought it desirable not to treat this meeting as a purely statutory one, but that the directors should meet the desire of many of the shareholders by stating exactly what had been done since they came into office, and the prospects of future development. The company's capital had originally been fixed at £440,000, divided into £170,000 of £10 preference shares, £170,000 of £10 ordinary, and £100,000 of £100 debentures. Of that amount, £113,330 had been paid to the vendors as founders' shares, as well as £33,300 of debentures. That left £226,670 of preference and ordinary shares to be allotted to the various applicants. Of that £226,670, the whole had been fully subscribed, without a single share having been underwritten. Of the debentures, out of £66,600 (the balance of the £100,000, after deducting the £33,300 to be allotted to the vendors), £51,100 had been taken up, leaving a balance of £15,000, the only balance unallotted of the entire capital, which it was the directors' intention not to allot until they required the money. The company's capital account was therefore summed up in the description that "the whole of the capital has been subscribed for and allotted," with the exception of £15,000 worth of debentures which they did not require to allot. The company's managing director and Mr. Connolly, the works manager, had visited the United States since the company's incorporation for the purpose of examining into the business and working of the factory at Passaic, New Jersey, and the special processes carried on there for the purpose of working similar plant at the company's Manchester works. The managing director had returned, Mr. Connolly was on his way home. The former reported, and the speaker believed Mr. Connolly agreed with him, that the works were in first class order, well organised, admirably arranged and fully occupied. Assuming the turn-out for 1887 as the unit 100, then the turn-out in 1888 represented 164; in 1889, 224; and in 1890, so far, the satisfactory figure of 450. In other words, the investigation had shown that the output at the American works had become four-and-a-half times what it was in 1887. In addition to the founders' shares named in the prospectus, the directors who formed the American committee had subscribed for considerably over £60,000 in shares, and paid for them in the ordinary way. The title to the American factory had been thoroughly examined and approved by the solicitors, Messrs. Davies, Short and Townsend, of New York. The whole of the purchase money had been paid, and the property in America had been invested in the Central Trust Company of New York, as trustees for the debenture holders. From personal inspection the company's managers reported themselves satisfied that the business was a sound and lucrative one with every prospect of a large and continuous increase; and that there was an immense advantage in having a factory both at New York and Manchester. With regard to the Manchester works, the business had been taken over and paid for, and the company had since acquired a plot of vacant land of about an acre, bounded on one side by the company's own factory, on another by the Rochdale Canal, and on the other two sides by good roads. On this they were actively working an improved fireproof factory for the manufacture of the company's specialité of high-class okonite wires and cables, and the necessary machinery was well in hand. The works were in full swing manufacturing the various classes of insulated wires, and orders were coming in most satisfactorily. Messrs. Shaw and Connolly had agreed to serve the company for a term of years, and, as both gentlemen had technical and business knowledge second to none in the manufacture of insulated wire, the directors had every reason to anticipate that, with the capital at their command, the English business would soon rival, if it did not exceed, the American. Certain statements as to the profits of the year had been made in the prospectus, and some shareholders had questioned the profits for 1889 and 1890 of Shaw and Connolly (which, the meeting would remember, had been taken as estimated, and not as ascertained), and also the profits of 1890 of the old Okonite Company, these profits not having been ascertained by a competent accountant at the date of the prospectus. However, the directors were now in possession of Messrs. Price and Waterhouse's report and statement, which showed the statements in the prospectus to be well under the actually ascertained amount. With regard, however, to the profits of 1890 of the old company in America, the directors had not yet received Messrs. Price and Waterhouse's certificate. The directors had cabled to New York for the most recent information as to the progress of the audit, for of course it was desirable to know as far as possible the actual facts with regard to the property acquired; and they had received from the New York office, under date September 26th, a letter which stated that the books were not quite closed, but that approximately it was thought that the profits would be considerably larger than the prospectus claimed they would be. The actual result had since been cabled for, but the directors had not yet received the certificate. However, from what the general manager said, he (the speaker) did not doubt that the statements referred to would be abundantly justified by the facts. Of course the directors could have no great experience in the management of the concern during that short period in office, but he thought he might say that the view which his colleagues, and which he himself would desire to see carried out, would be to manage the concern with an eye to making it a substantial commercial undertaking, and not with a view merely to create a temporary fictitious value in the shares of the company. During the last three years of the Okonite Company's working they had never had returned to them a single yard of okonite wire as being of defective insulation. The whole of the wires were guaranteed to a standard far in excess of the working requirements, and were fully tested 100 per cent. over the company's guarantee before leaving the works. The same system would be adopted in England, as, although it tended to slightly increase the cost of production, it was important that their electrical insulated conductors should be of a high class, and absolutely reliable. The scrip certificates had been issued, and application had been made to the Stock Exchange for a special settlement and quotation in the official list. As showing how active the English business of the company was, the speaker produced an order from an English firm for 135,000 feet of okonite wire.

After several shareholders had expresssed their satisfaction with the statements jnst made, an extraordinary general meeting was held, as announced, and the following resolution, which, the chairman explained, was intended to make certain minor alterations in the articles of association, which had been called for by the Stock Exchange, was passed, and the proceedings terminated.

Resolution.—"That the articles of association of the company be altered in the following manner:—

"(*a*) In clause 35, that the portion of the clause following the words 'provided that' be struck out and the following inserted: 'The funds of the company shall not be expended in the purchase of or lent upon the security of its own shares.'

"(*b*) In clause 72, that the following words be added at the end of the clause: 'And, unless he shall do so, he shall be deemed to have agreed to take the said shares from the company, and the same shall be forthwith allotted to him accordingly.'

"(*c*) In clause 116, that the following words be added at the end of the clause: 'And a copy of such balance sheet shall be posted to each member at his registered address at least eight days before such ordinary general meeting.'"

Brazilian Submarine Telegraph Company, Limited.—The accounts, subject to audit, show a profit sufficient to enable the directors to recommend a final dividend of 3s. per share, making, with previous distributions, a total dividend of 6 per cent. for the year ended 30th June, 1890, and also the payment of a bonus of 3s. per share, both free of income tax, which, together, will amount to £39,000, being a distribution in the aggregate of 7½ per cent. for the past year, leaving a balance of £42,416 18s. 1d., of which amount £40,000 has been placed to the reserve fund, increasing that fund to £352,626 2s. 11d., and £2,416 16s. 1d. carried forward.

A Franco-Russian Company is about to organise a new telegraphic agency in Servia and the other Balkan countries, the Servian Government having declined to renew its connection with the Vienna Correspondence Bureau.

The Telephone Company of Austria, Limited, notifies that the usual half-yearly dividend to the 30th ult. on the preference shares, at the rate of 6 per cent. per annum, has been declared by the board.

Reuter's Telegram Company, Limited.—The directors have declared an interim dividend at the rate of 5 per cent. per annum, free of income tax, for the half year ending the 30th June last.

TRAFFIC RECEIPTS.

The Brazilian Submarine Telegraph Company, Limited. The traffic receipts for the week ending October 3rd, were £5,323.

The Cuba Submarine Telegraph Company, Limited. The receipts for the month of September were £3,000, as compared with £2,372 in the corresponding month o last year. The receipts for the month of June, estimated at £3,300, realised £3,324.

The Direct Spanish Telegraph Company, Limited. The estimated receipts for the month of September were £2,526, against £2,139 in the corresponding period of last year.

The Great Northern Telegraph Company, Limited. The receipts for the month of September amounted to £25,800; 1st January—30th September 1890, £206,800; corresponding months 1889, £203,200; do. 1888, £202,600.

West India and Panama Telegraph Company, Limited. The estimated traffic receipts for the half month ended September 30th, show an increase of £187 as compared with the corresponding period.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending October 3rd, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £4,163.

SHARE LIST OF ELECTRICAL COMPANIES.

Present Amount Issued.	Name.	Stock or Share.	Closing Quotation. (October 2).	Closing Quotation. (October 9.)	Business done during week ending October 9, 1890.	
					Highest.	Lowest.
£						
250,000	African Direct Telegraph, Ltd., 4 p. c. Deb. Regd. and to Bearer	100	98 —101	98 —101		
1,549,160	Anglo-American Telegraph, Limited	Stock	51 — 52	50½— 51½	51	...
2,725,420	Do. do. 6 p. c. Preferred	Stock	87 — 88	87 — 88	88½	87
2,725,420	Do. do. Deferred	Stock	14¾— 14⅜	14¼— 14¾	14½	14⅛
130,000	Brazilian Submarine Telegraph, Limited	10	11¾— 12¼	11¾— 12¼	12⅛	11⅞
99,000	Do. do. 5 p. c. Bonds...	100	100 —102	100 —102		
75,000	Do. do. 5 p. c. 2nd Series, repayable June, 1906	100	103 —107	103 —107		
63,416	Brush Electric Engineering Ordinary, Nos. 1 to 63,416... ...	3	1½— 2	1½— 2		
63,416	Do. do. Preference, Nos. 1 to 63,416 ...	2	1¾— 2	1⅝— 1⅞		
7,216,000	Commercial Cable, Capital Stock	$100	102 —104 xd	102 —104	103½	...
224,850	Consolidated Telephone Construction and Maintenance, Ltd. ...	14/-	½— ⅝	½— ⅝		
20,000	Crompton & Co., Limited, 7 p. c. Pref. Shares, Nos. 1 to 20,000	Stock	5¼— 5¾	5¼— 5¾		
16,000	Cuba Telegraph, Limited	10	11½— 12½	11½— 12½	11¾	...
6,000	Do. do. 10 p. c. Preference	10	17 — 18	17 — 18		
12,931	Direct Spanish Telegraph, Limited ... (£4 only paid)	5	4 — 4½	4 — 4½		
6,000	Do. do. 10 p. c. Preference	5	9 — 10	9 — 10		
60,710	Direct United States Cable, Limited, 1877	20	10⅜— 10⅝	10⅜— 10⅝	10⅝	10½
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	14 — 14¼	14 — 14¼	14¼	14
70,000	Do. 6 p. c. Preference	10	15 — 15½	15 — 15½	15¼	...
200,000	Do. 5 p. c. Debs. (1879 issue), repay. Aug., 1899	100	106 —109	106 —109	108	106½
1,200,000	Do. 4 p. c. Mortgage Debenture Stock	Stock	104 —107	104 —107	105½	...
250,000	Eastern Extension, Australasia and China Telegraph, Limited	10	14⅛— 14⅜	14⅛— 14⅜	14⅜	14⅛
320,000	Do. 6 p. c. Debentures, repay. February, 1891	100	100 —102	100 —102		
446,100	Do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. ...	100	101 —104	102 —105		
12,500	Do. 5 p. c. Debentures, 1890, redeem. ann. drawings ...	100	101 —104	102 —105	102½	...
367,900	Eastern and South African Tel., Ltd., 5 p. c. Mort. Deb., 1900...	100	101 —104	101 —104	102⅝	...
45,000	Electric Construction, Limited, Nos. 101 to 45,100	10	7¾—8¼	7¾— 8¼	7¾	...
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	4¾— 5¼	4¾— 5¼		
46,700	Elmore's Patent Copper Depositing, Ltd., Nos. 23,001 to 70,000	2	5 — 5½	5 — 5½	5⅝	5¼
67,385	Elmore's Wire Manufacturing, Limited, Nos. 1 to 67,385 issued at 1 pm. all paid (£1½ paid)	2	2¼— 2¾	2¼— 2¾	2½	2¼
19,700	Fowler-Waring Cables, Nos. 301 to 20,000 ...(£3 only paid)	5	3½— 4	2½— 3		
180,227	Globe Telegraph and Trust, Limited	10	8⅞— 9⅛	8⅞— 9⅛	8⅞	...
180,042	Do. do. 6 p. c. Preference	10	14¾— 15	14¾— 15	15	14¾
150,000	Great Northern Tel. Company of Copenhagen	10	15¾— 16¼	15¾— 16¼	16	$15\frac{15}{16}$
40,000	Do. do. 5 p. c. Debs. (issue of 1881) ...	100	100 —103	101 —104		
250,000	Do. do. do. (issue of 1883) ...	100	104 —107	104 —107		
9,334	Greenwood and Batley, Ltd., Ordinary, Nos. 4,667 to 14,000 ...	10	11½— 12½	11½— 12½		
5,334	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	11½— 12½	11½— 12½		
41,600	India-Rubber, Gutta-Percha and Telegraph Works, Limited ...	10	18½— 19½	18 — 19	$18\frac{15}{16}$	$18\frac{9}{16}$
200,000	Do. do. 4½ p. c. Deb., 1896...	100	100 —102 xd	102 —104	101¾	...
17,000	Indo-European Telegraph, Limited...	25	36 — 38	36 — 38	36¼	...
38,348	London Platino-Brazilian Telegraph, Limited	10	6½— 7½	6½— 7½		
100,000	Do. do. do. 6 p. c. Debentures ...	100	105 —108	105 —108		
49,900	*Metropolitan Electric Supply, Limited, Nos. 6,101 to 50,000 ...	10	4 — 4½	5½— 6½	5¾	5⅝
436,700	National Telephone, Limited, Nos. 1 to 436,700	5	4½— 4¾	4⅜— 4⅜	$4\frac{9}{16}$	4½
15,000	Do. 6 p. c. Cum. 1st Preference	10	12¼— 12¾	12¼— 12¾	12½	$12\frac{5}{16}$
15,000	Do. 6 p. c. Cum. 2nd Preference (£8 only paid)	10	10 — 10½	10 — 10½		
220,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11/- only paid)	1	⅛— ⅜	⅛— ⅜		
9,000	Reuter's, Limited	8	8¼— 8¾	8¼— 8¾		
209,750	South of England Telephone, Ltd., Ordinary, Nos. 1 to 2,000, 2,501 to 3,500, 93,251 to 300,000	1	⅛— ...	⅛— ...		
20,000	Do. 6 p. c. Cum. Pref., Nos. 1 to 20,000 (£3½ only paid)	5	2½— 3	2½— 3		
3,381	Submarine Cables Trust	Cert.	113 —117	113 —117		
78,949	Swan United Electric Light, Limited ... (£3½ only paid)	5	5¼— 5¾	5¼— 5¾	5⅞	5⅝
37,350	Telegraph Construction and Maintenance, Limited	12	43 — 45	43 — 45	44½	43⅞
150,000	Do. do. do. 5 p. c. Bonds, red. 1894	100	100 —102	100 —102		
55,000	United River Plate Telephone, Limited	5	3½— 4	3½— 4		
146,000	Do. do. 5 p. c. Debenture Stock... ...	Stock	90 — 94	90 — 94		
100,000	Do. do. 7 p. c. Debs., Nos. 1 to 1,000 ...	100	... ...	... ...		
15,609	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	9 — 10	8 — 9		
300,000	Do. do. do. 5 p. c. Debentures	100	99 —102	98 —101	100¼	99¾
30,000	West Coast of America Telegraph, Limited	10	4½— 5	4½— 5		
150,000	Do. do. do. 8 p. c. Debs, repay. 1902 ...	100	102 —107	102 —107	103½	...
64,572	Western and Brazilian Telegraph, Limited	15	11¼— 11¾	11¼— 11¾	11⅝	11½
26,986	Do. do. do. 5 p. c. Cum. Preferred	7½	6⅞— 7⅛	6⅞— 7⅛	7	7⅛
26,986	Do. do. do. 5 p. c. Deferred	7½	4¾— 5¼	4¾— 5¼	4⅞	4¾
200,000	Do. do. do. 6 p. c. Debentures "A," 1910...	100	103 —106	103 —106		
250,000	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	103 —106	103 —106		
88,321	West India and Panama Telegraph, Limited	10	3 — 3¼	2⅞— 3⅛	3⅛	$2\frac{15}{16}$
34,563	Do. do. do. 6 p. c. 1st Preference ...	10	11½— 12	11½— 12	$11\frac{11}{16}$	11½
4,669	Do. do. do, 6 p. c. 2nd Preference ...	10	14 — 15	14 — 15		
1,336,000	Western Union of U.S. Tel., 7 p. c. 1st Mort (Building) Bonds	$1,000	122 —127	122 —127		
179,300	Do. do. 6 p. c. Sterling Bonds	100	99 —103	99 —103		
42,853	*Westmstr. Elec. Sup. Corp., Ord., Nos. 101 to 42,953 (£2 only paid)	5	1 — 1½	1¼— 1¾	1½	...

* Subject to Founders Shares.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Blackpool Electric Tramway Company, Limited, £10 (£6½ paid), 7⅛—7⅜.—Elmore Copper Depositing Priorities, 7 —7½.—Elmore's French Patent Copper Depositing shares of £2 (issued at 10s. premium, 15s. paid), $1\frac{5}{16}$—$1\frac{7}{16}$.—House-to-House Company (£5 paid), 5 —5½.—International Okonite, Ordinary of £10 (£7 paid), 6¾—7¼.—London Electric Supply Corporation, Ordinary (£5 paid), 2⅜—2⅝.—Manchester Edison and Swan Company, £9 (£1 paid) 11/- —13/-.

BANK RATE OF DISCOUNT.—5 per cent. (25th September 1890).

THE ELECTRO-MAGNET.*

By Prof. SILVANUS P. THOMPSON, D.Sc., B.A., M.I.E.E.

(*Continued from page* 407.)

HYSTERESIS.

I have already drawn attention to the difference between the ascending and descending curves of magnetisation, and may now point out that this is a part of a set of general phenomena of residual effects. The best known of these effects is, of course, the existence in some kinds of iron, and notably in steel, of a remanent or sub-permanent magnetisation after the magnetising force has been entirely removed. To this retardation of effects behind the causes that produce them the name of "hysteresis" has been given by Prof. Ewing. If a piece of iron is subjected to a magnetising force which increases to a maximum, then is decreased down to zero, then reversed and carried to a negative maximum, then decreased again to zero, and so carried round an entire cycle of magnetic operations, it is observed that the curves of magnetisation form a closed area similar in general to those shown in fig. 21. This closed area represents the work which has been wasted or dissipated in subjecting the iron to these alternate magnetising forces. In very soft iron, where the ascending and descending curves are close together, the enclosed area is small; and, as a matter ot fact, very little energy is dissipated in a cycle of magnetic operations. On the other hand, with hard iron, and particularly with steel, there is a great width between the curves, and there is great waste of energy. Hysteresis may be regarded as a sort of internal or molecular magnetic friction, by reason of which alternate magnetisations cause the iron to grow hot. Hence the importance of understanding this curious effect, in view of the construction of electromagnets that are to be used with rapidly alternating currents. The following figures of Table V. give the number of watts (1 watt = $\frac{1}{476}$ of a horse-power) wasted by hysteresis in well-laminated soft wrought iron when subjected to a sucession of rapid cycles of magnetisation :—

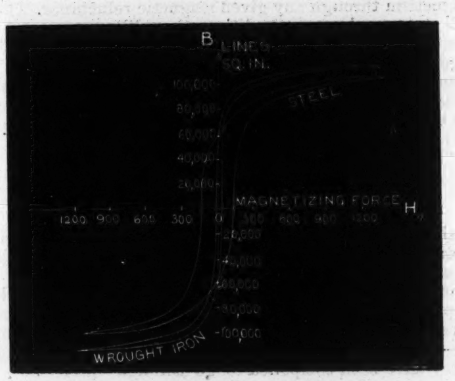


FIG. 21.—CURVES OF HYSTERESIS.

TABLE V.—WASTE OF POWER BY HYSTERESIS.

B	$B_{\prime\prime}$	Watts wasted per cubic foot at 10 cycles per second.	Watts wasted per cubic foot at 100 cycles per second.
4,000	25,800	40	400
5,000	32,250	57·5	575
6,000	38,700	75	750
7,000	45,150	92·5	925
8,000	51,600	111	1,110
10,000	64,500	156	1,560
12,000	77,400	206	2,060
14,000	90,300	262	2,620
16,000	103,200	324	3,240
17,000	109,650	394	3,940
18,000	116,100	487	4,870

It will be noted that the waste of energy increases as the magnetisation is pushed higher and higher in a disproportionate degree, the waste when B is 18,000 being six times that when B is 6,000. In the case of hard iron or of steel the heat waste would be far greater.

Another kind of after effect was discovered by Ewing, and named by him "viscous hysteresis." This is the name given to the gradual creeping up of the magnetisation when a magnetic force is applied with absolute steadiness to a piece of iron. This gradual creeping up may go on for half-an-hour or more and amount to several per cent. of the total magnetisation.

Another important matter is that all such actions as hammering, rolling, twisting, and the like, impair the magnetic quality of annealed soft iron. Annealed wrought iron which has never been touched by a tool shows hardly any trace of residual magnetisation, even after the application of magnetic forces. But the touch of the file will at once spoil it. Sturgeon pointed out the great importance of this point. In the specification for tenders for instruments for the British Postal Telegraphs, it is laid down as a condition to be observed by the constructor, that the cores must not be filed after being annealed. The continual hammering of the armature of an electro-magnet against the poles may in time produce a similar effect.

FALLACIES AND FACTS ABOUT ELECTRO-MAGNETS.

I will conclude this lecture by stating a few of the fallacies that are current about electro-magnets and will add to them a few facts, some of which seem paradoxical. The refutation of the fallacies and the explanation of the facts will come in due course.

Fallacies.—The attraction of an electro-magnet for its armature varies inversely, as the square of its distance from the poles.

The outer windings of an electro-magnet are necessarily less effective than those that are close to the iron.

Hollow iron cores are as good as solid cores of the same size.

Pole pieces add to the lifting power of an electro-magnet.

It hurts an electromagnet (or, for that matter, a steel magnet) to pull off the keeper suddenly. [It is the sudden slamming on that in reality hurts it.]

The resistance of the coil of an electro-magnet ought to be equal to the resistance of the battery.

A coil wound left-handedly magnetises a magnet differently from a coil wound right-handedly. [It is not a question of winding of coil but of circulation of current.]

Thick-wire electro-magnets are less powerful than thin-wire electro-magnets.

A badly insulated electro-magnet is more powerful than one that is well insulated.

A square iron core is less powerful (as Dal Negro says, eighteen fold!) than a round core of equal weight.

The attraction of an electro-magnet for its keeper is necessarily less strong (one-third according to Du Moncel) sideways than when the keeper is in front of the poles.

Putting a tube of iron outside the coils of an electro-magnet makes it attract a distant armature more powerfully.

Facts.—A bar electro-magnet with a convex pole holds on tighter to a flat-ended armature than one with a flat pole does.

A thin round disc of iron laid upon the flat round end of an electro-magnet (the pole end being slightly larger than the disc) the disc is not attracted, and will not stick on, even if laid down quite centrally.

If a flat armature of iron be presented to the poles of a horseshoe electro-magnet the attraction at a short distance is greater, if the armature is presented flankways, than if it is presented edgeways. On the contrary, the tractive force in contact is greater, edgeways than flankways.

Electro-magnets with long limbs are practically no better than those with short limbs for sticking on to masses of iron.

LECTURE II.—DELIVERED JANUARY 27TH, 1890.

General Principles of Design and Construction.—Principle of the Magnetic Circuit.

To-night we have to discuss the law of the magnetic circuit in its application to the electro-magnet, and in particular to dwell upon some experimental results which have been obtained from time to time by different authorities as to the relation between the construction of the various parts of an electro-magnet, and the effect of that construction on its performance. We have to deal not only with the size, section, length, and material of the iron cores, and of the armatures of iron, but we have to consider also the winding of the upper coil, and its form; and we have to speak in particular about the way in which the shaping of the core and of the armature affects the performance of the electro-magnet in acting on its armature, whether in contact or at a distance. But before we enter on the last more difficult part of the subject, we will deal solely and exclusively with the law of force of the magnet upon its armature when the two are in contact with one another; in other words, with the law of traction.

I alluded in a historical manner in my first lecture to the principle of the magnetic circuit, telling you how the idea had gradually grown up, perforce, from a consideration of the facts. The law of the magnetic circuit was, however, first thrown into shape in 1873 by Prof. Rowland, of Baltimore. He pointed out that if you consider any simple case, and find (as electricians do for the electric circuit) an expression for the magnetising force which tends to drive the magnetism round the circuit, and divide that by the resistance to magnetisation reckoned also all round the circuit, the quotient of those two gives you the total amount of flow or flux of magnetism. That is to say, one may calculate the quantity of magnetism that passes in that way round the magnetic circuit in exactly the same way as one calculates the strength of the electric current by the law of Ohm. Rowland, indeed, went a great deal further than this, for he applied this very calculation to the experiments made by Joule more than 30 years before, and from those experiments deduced the degree of magnetisation to which Joule had driven the iron of his magnets, and by inference obtained the amount of current that he had been causing to circulate. Now this law requires to be written out in a form that can be used for future calculation. To put it in words without any symbols, we must first reckon out from the number of turns of wire in the coil, and the number of ampères of current which circulates in them, the whole *magneto-motive force*—the whole of that which tends to drive magnetism along the piece of iron—for it is, in fact, proportional to the strength of the current, and the number of times it circulates. Next we must ascertain the resistance which the magnetic circuit offers to the passage of the magnetic lines. I here avowedly use Joule's own expression, which was afterwards adopted by Rowland, and, for short, so as to avoid having four words, we may simply call it the *magnetic resistance.* Mr. Heaviside has suggested as an advisable alternative term, magnetic *reluctance,* in order that we may not confuse the resistance to magnetism in the magnetic circuit with the resistance to the flow of current in an electric circuit. However, we need not quarrel about terms; magnetic reluctance is sufficiently expressive. Then having found these two, the quotient of them gives us a number representing—I must not call it the strength of the magnetic current—I will call it simply the quantity or number of magnetic lines which flow round the circuit; or if we could adopt a term which is used on the Continent, we might call it simply the *magnetic flux:* the flux of magnetism being the analogue of the flow of electricity in the electric law. The law of the magnetic circuit may then be stated as follows:—

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* Cantor Lecture. Delivered before the Society of Arts, January 20th, 1890.

$$\text{Magnetic flux} = \frac{\text{magneto-motive force}}{\text{reluctance}}.$$

However, it is more convenient to deal with these matters in symbols, and therefore the symbols which I use, and have long been using, ought to be explained to you. For the number of spirals in a winding I use the letter s; for the strength of current, or number of ampères, the letter i; for the length of a bar, or core, I am going to use the letter l; for the area of cross section, the letter A; for the permeability of the iron which we discussed in the last lecture, the Greek symbol μ; and for the total magnetic flux, the number of magnetic lines, I use the letter N. Then our law becomes as follows:—

$$\text{Magneto-motive force } \frac{4\pi s i}{10};$$

$$\text{Magnetic reluctance } \Sigma \frac{l}{A\mu};$$

$$\text{Magnetic flux} \ldots\ldots N = \frac{\dfrac{4\pi \,.\, s i}{10}}{\Sigma \dfrac{l}{A\mu}}$$

If we take the number of spirals and multiply by the number of ampères of current, so as to get the whole amount of circulation of electric current expressed in so many ampère-turns, and multiply by 4π, and divide by ten, in order to get the proper unit (that is to say, multiply it by 1·257), that gives us the magneto-motive force. For magnetic reluctance, calculate out the reluctance exactly as you would the resistance of an electric conductor to the flow of electricity, or the resistance of a conductor of heat to the flow of heat; it will be proportionate to the length, inversely proportional to the cross section, and inversely proportional to the conductivity, or, in the present case, to the magnetic permeability. Now if the circuit is a simple one, we may simply write down here the length, and divide it by the area of the cross section and the permeability, and so find the value of the reluctance. But if the circuit be not a simple one, if you have not a simple ring of iron of equal section all round, it is necessary to consider the circuit in pieces as you would an electric circuit, ascertaining separately the reluctance of the separate parts, and adding all together. As there may be a number of such terms to be added together, I have prefixed the expression for the magnetic reluctance by the sign Σ of summation. But it does not by any means follow because we can write a thing down as simply as that, that the calculation out of it will be a very simple matter. In the case of magnetic lines, we are quite unable to do as one does with electric currents to insulate the flow. An electric current can be confined (provided we do not put it in at 10,000 volts pressure, or anything much bigger than that) to a copper conductor by an adequate layer of adequately strong—and I use the word "strong" both in a mechanical and electrical sense—of adequately strong insulating material. There are materials whose conductivity for electricity, as compared with copper, may be regarded perhaps as millions of millions of millions of times less; that is to say, they are practically perfect insulators. There are no such things for magnetism. The most highly insulating substance we know of for magnetism is certainly not 10,000 times less permeable to magnetism than the most highly magnetisable substance we know of, namely, iron in its best condition; and when one deals with electro-magnets where curved portions of iron are surrounded with copper, or with air, or other insulating material, one is dealing with substances whose permeability, instead of being infinitely small, compared with that of iron, is quite considerable. We have to deal mainly with iron when it has been well magnetised. Its permeability, compared with air, is from 1,000 to 100 roughly; that is to say, the permeability of air compared with the iron is not less than from $\frac{1}{100}$th to $\frac{1}{1000}$th part. That means that it is quite possible to have a very considerable leakage of magnetic lines from iron into air occurring to complicate one's calculations, and prevent an accurate estimate being made of the true magnetic reluctance of any part of the circuit. Suppose, however, that we have got over all these difficulties, and made our calculations of the magnetic reluctance; then dividing the magneto-motive force by the reluctance gives us the whole number of magnetic lines.

There, then, is in its elementary form the law of the magnetic circuit stated exactly as Ohm's law is stated for electric circuits. But as a general rule one requires this magnetic law for certain applications, in which the problem is not to calculate from those two quantities what the total of magnetic lines will be. In most of the cases a rule is wanted for the purpose of calculating back. You want to know how to build a magnet so as to give you the requisite number of magnetic lines. You start by assuming that you need to have so many magnetic lines, and you require to know what magnetic reluctance there will be, and how much magneto-motive force will be needed. Well, that is a matter precisely analogous to those which every electrician comes across. He does not always want to use Ohm's law in the way in which it is commonly stated, to calculate the current from the electromotive force and the resistance; he often wants to calculate what is the electromotive force which will send a given current through a known resistance. And so do we. Our main consideration to-night will be devoted to the question how many ampère turns of current circulation must be provided in order to drive the required quantity of magnetism through any given magnetic reluctance. Therefore, we will state our law a little differently. What we want to calculate out is the number of ampère turns required. When once we have got that, it is easy to say what the copper wire must consist of; what sort of wire, and how much of it. Turning then to our algebraic rule, we must transform it, so as to get all the other things beside the ampère turns, to the other side of the equation. So we write the formula:—

$$s i = \frac{N \,.\, \Sigma \dfrac{l}{A\mu}}{1{\cdot}257}$$

We shall have then the ampère turns equal to the number of magnetic lines we are going to force round the circuit multiplied by the sum of the magnetic reluctances divided by 1·257. Now, this number, 1,257, is the constant that comes in when the length, l, is expressed in centimetres, the area in square centimetres, and the permeability in the usual numbers. Many persons, unfortunately—I say so advisedly, because of the waste of brain labour that they have been compelled to go through—prefer to work in inches and pounds and feet. They have, in fact, had to learn tables instead of acquiring them naturally without any learning. If the lengths be specified in inches, and areas in square inches, then the constant is a little different. The constant in that case, for inches and square inch measures, is 0·3132, so that the formula becomes:—

$$s i = N \times \Sigma \frac{l''}{A''\mu} \times 0{\cdot}3132.$$

Here it is convenient to leave the law of the magnetic circuit, and come back to it from time to time as we require. What I want to point out before I go to any of the applications is, that with the guidance provided by this law, one after another the various points that come under review can be arranged and explained, and that there does not now remain—if one applies this law with judgment—a single fact about electro-magnets which is either anomalous or paradoxical. Paradoxical some things may seem in form, but they all reduce to what is perfectly rational when one has a guiding principle of this kind to tell you how much magnetisation you will get under given circumstances, or to tell you how much magnetising power you require in order to get a given quantity of magnetisation. I am using the word "magnetisation" there in the popular sense, not in the narrow mathematical sense in which it has sometimes been used (*i.e.*, for the magnetic moment per unit cube of the material). I am using it simply to express the fact that the iron or air, or whatever it may be, has been subjected to the process which results in there being magnetic lines of force induced through it.

Now let us apply this law of magnetic circuit, in the first place, to the traction, that is to say, the lifting power of electro-magnets. The law of traction I assumed in my last lecture, for I made it the basis of a method of measuring the amount of permeability. The law of magnetic traction was stated once for all by Maxwell, in his great treatise, and it is as follows:—

$$P\ (\text{dynes}) = \frac{B^2 A}{8\pi},$$

where A is the area in square centimetres. This becomes

$$P\ (\text{grammes}) = \frac{B^2 A}{8\pi \times 981}.$$

That is, the pull in grammes per square centimetre is equal to the square of the magnetic induction, B (being the number of magnetic lines to the square centimetre), divided by 8π, and divided also by 981. To bring grammes into pounds you divide by 453·6; so that the formula then becomes:—

$$P\ (\text{lbs.}) = \frac{B^2 A}{11{,}183{,}000};$$

or if square inch measures are used:—

$$P\ (\text{lbs.}) = \frac{B_{''}^{2} A''}{72{,}134{,}000}.$$

To save future trouble we will now calculate out from the law of traction the following table, in which the traction in grammes per square centimetre or in pounds per square inch, is set down opposite the corresponding value of B.

TABLE VI.—MAGNETISATION AND MAGNETIC TRACTION.

B lines per square centimetre.	B,, lines per square inch.	Dynes per square centimetre.	Grammes per square centimetre.	Kilogrammes per square centimetre.	Pounds per square inch.
1,000	6,450	39,790	40·56	·0456	·577
2,000	12,900	159,200	162·3	·1623	2·308
3,000	19,350	358,100	365·1	·3651	5·190
4,000	25,800	636,600	648·9	·6489	9·228
5,000	32,250	994,700	1,014	1·014	14·39
6,000	38,700	1,432,000	1,460	1·460	20·75
7,000	45,150	1,950,000	1,987	1·987	28·26
8,000	51,600	2,547,000	2,596	2·596	36·95
9,000	58,050	3,223,000	3,286	3·286	46·72
10,000	64,500	3,979,000	4,056	4·056	57·68
11,000	70,950	4,815,000	4,907	4·907	69·77
12,000	77,400	5,730,000	5,841	5·841	83·07
13,000	83,850	6,725,000	6,855	6·855	97·47
14,000	90,300	7,800,000	7,550	7·550	113·1
15,000	96,750	8,953,000	9,124	9·124	129·7
16,000	103,200	10,170,000	10,390	10·39	147·7
17,000	109,650	11,500,000	11,720	11·72	166·6
18,000	116,100	12,890,000	13,140	13·14	186·8
19,000	122,550	14,360,000	14,630	14·63	208·1
20,000	129,000	15,920,000	16,230	16·23	230·8

This simple statement of the law of traction assumes that the distribution of the magnetic lines is uniform all over the area we are considering; and that, unfortunately, is not always the case. When the distribution is not uniform, then the mean value of the squares becomes greater than the square of the mean value, and consequently the pull of the magnet at its end face may, under certain circumstances, become greater than the calculation would lead you to expect—greater than the average of B would lead you to suppose. If the distribution is not uniform over the area of contact, then the accurate expression for the tractive force (in dynes) will be

$$P = \frac{1}{8\pi} \int B^2 \, d A,$$

the integration being taken over the whole area of contact.

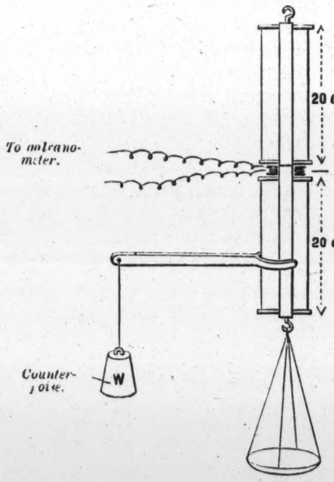


FIG. 22.—BOSANQUET'S VERIFICATION OF THE LAW OF TRACTION.

This law of traction has been verified by experiment. The most conclusive investigations were made about 1886 by Mr. R. H. M. Bosanquet, of Oxford, whose apparatus is depicted in fig. 22. He took two cores of iron, well faced, and surrounded them both by magnetising coils, fastened the upper one rigidly, and suspended the other one on a lever with a counterpoise weight. To the lower end of this core he hung a scale pan, and measured the traction of one upon the other when a known current was circulating a known number of times round the coil. At the same time he placed an exploring coil round the joint, that exploring coil being connected, in the manner with which we were experimenting last week, with a ballistic galvanometer; so that at the moment when the two surfaces parted company, or at the moment when the magnetisation was released by stopping the magnetising current, the galvanometer indication enabled him to say exactly how many magnetic lines went through that exploring coil. So that, knowing the area, you could calculate the number per square centimetre, and you could therefore compare B^2 with the pull per square centimetre obtained directly on the scale-pan. Bosanquet found that even when the surfaces were not absolutely perfectly faced the correspondence was very close indeed, not varying by more than 1 or 2 per cent. except with small magnetising forces, say forces less than 5 C.G.S. units. When one knows how irregular the behaviour of iron is when the magnetising forces are so small as this, one is not astonished to find a lack of proportionality. The correspondence was, however, sufficiently exact to say that the experiments verified the law of traction, that the pull is proportional to the square of the magnetic induction through the area, and integrated over that area.

(To be continued.)

NEW PATENTS—1890.

14077. "Automatic transmitter for submarine cables or long telegraph lines." T. J. WILMOT. Dated September 8.

14090. "Improvements in oil cans especially adapted for use on electrical installations." A. J. JARMAN. Dated September 8.

14155. "Improvements connected with switch boards for telephonic systems." H. T. O. FRASER and J. W. BROWN. Dated September 9.

14168. "Improvements in tools for the making of splices in submarine and other telegraph cables, ropes, and cables." F. FRASI. Dated September 9.

14191. "Improvements relating to electric railways." M. W. DEWEY. Dated September 9. *(Complete.)*

14193. "Improvements in means or apparatus for controlling, regulating, or automatically interrupting and indicating electric currents." R. LANGHANS. Dated September 9.

14196. "Improvements in incandescent electric lamps." W. R. LAKE. (Communicated by J. B. Tibbits, United States.) Dated September 9.

14197. "Improvements relating to the use of electric motors and to the regulation or control of machinery operated thereby." W. R. LAKE. (Communicated by the Thomson-Houston International Electric Company, United States.) Dated September 9. *(Complete.)*

14202. "Improvements in apparatus for receiving payments, and for permitting the use of telephonic apparatus in exchange therefor." W. R. LAKE. (Communicated by P. Bonamico, Italy.) Dated September 9.

14204. "An improved electric miners' safety lamp." G. C. LEVEY. Dated September 9.

14260. "Improvements in electric or magnetic carrier systems, otherwise known as port-electrics." H. J. HADDAN. (Communicated by J. T. Williams, United States.) Dated September 10. *(Complete.)*

14341. "Improvements in electrical apparatus for reproducing sound." J. E. ROULEZ. Dated September 11.

14349. "An improvement in electric meters." SIEMENS BROS. AND CO., LIMITED. (Communicated by Siemens and Halske, Germany.) Dated September 11.

14368. "An automatic electric lighting contrivance for staircases." L. A. THRANITZ. Dated September 11.

14394. "Improvements in electric bells." F. W. WHITE and E. F. FURTADO. Dated September 12.

14459. "Improvements in electric bells or sounding apparatus." E. EDWARDS. (Communicated by G. Bénard, France.) Dated September 13.

14460. "Improvements in electric bells." E. EDWARDS. (Communicated by G. Bénard, France.) Dated September 13.

14482. "An improved connection for electroliers or electric chandeliers." R. B. EVERED and T. RUDLING. Dated September 13.

14484. "An improved combined electric switch and connecting or coupling device." R. B. EVERED and T. RUDLING. Dated September 13.

14536. "Improvements relating to means for connecting glow lamps to their holders and for connecting together the parts of other electrical apparatus." H. J. F. VOIGT and J. STAUDT. Dated September 15.

14548. "Improvements in the art of and apparatus for telegraphing and telephoning and similar purposes." S. L. WIEGAND. Dated September 16. *(Complete.)*

14553. "Improvements in and relating to train signalling apparatus." R. S. HAMPSON and R. FORSTER. Dated September 16.

14603. "Improvements in electric signalling apparatus." W. R. LAKE. (Communicated by the Hall Signal Company United States.) Dated September 16. *(Complete.)*

14604. "Improvements relating to the heating of metals and other materials by electricity." M. W. DEWEY. Dated September 16. *(Complete.)*

14609. "Improvements in electrically propelled vehicles in the arrangement and connections of the motors and power transmitting devices thereof, and the method of operating the same, a portion of the invention being applicable to the transmission of power for other uses." B. J. B. Mills. (Communicated by E. H. Johnson, United States.) Dated September 16.

14613. "Electric-motor car." W. Robinson. Dated September 16. (*Complete.*)

14624. "Improvements in the manufacture of metallic articles by electrolysis and apparatus for that purpose." A. S. Elmore. Dated September 16.

14627. "Improvements in shadowless arc electric lamps." A. G. Melhuish. Dated September 16.

14634. "Improved apparatus for electric light signalling." E. F. Inglefield. Dated September 16. (*Complete.*)

14666. "Improvements in electric switches." J. Charters. Dated September 17.

14679. "Improvements in electrical alarm apparatus for shops, stores, and other purposes." W. Wilkinson and W. A. Sykes. Dated September 17.

14686. "Improvements relating to the preparation or treatment of carbons for electric lamps or lighting apparatus." W. R. Lake. (Communicated by Lacombe & Co., France.) Dated September 17.

14696. "Improved telegraphic relay." J. P. Bayly. (Communicated by J. M. Treber, United States.) Dated September 17.

14698. "Improvements in conductors for the distribution of electrical energy, and in apparatus connected therewith." R. E. B. Crompton and W. A. Chamen. Dated September 17.

14748. "Improvements in apparatus for electrically giving alarm from letter plates, post boxes, and other purposes." P. Williams. Dated September 18.

14776. "An improved process and means for the electro-deposition of metals." C. T. J. Vautin. Dated September 18.

14807. "An improvement in the supply of electricity in medical cases." J. Gnezda. Dated September 19.

14817. "Improvements in and relating to the distribution of electrical energy." R. Kennedy. Dated September 19. (*Complete*)

14830. "Improved means of accommodating electric wires in buildings." F. Walton. Dated September 19.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1889.

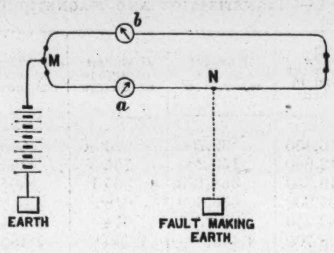
6544. "Improvements relating to electric incandescence lamps." A. A. Goldston. Dated April 16. 8d. The object of the invention is to provide such lamps with improved cut-outs, adapted to operate automatically when the carbons or light-giving conductors become destroyed. 5 claims.

6578. "Improvements in arc lamps." G. Hookham. Dated April 17. 8d. The feed mechanism is actuated by the weight of the upper carbon and the carbon holder. The descent of this weight is retarded by the eddy currents generated in a Foucault disc. 1 claim.

6675. "Improvements in electrically-driven fans." H. G. Watel. Dated April 18. 6d. The inventor converts the rim of the fan into the armature of an electro-dynamic machine, or he applies the ring armature of such a machine to the periphery of the fan, and converts the fixed framing within or against which the fan works into field electro-magnets, or he applies such field magnets to the framing. 2 claims.

A SPEEDY METHOD OF LOCALISING DEFECTS IN AN ELECTRIC LIGHTING CIRCUIT.

THIS is described by M. Henri Wilbrant (*La Lumière Electrique*), who recommends it for its simplicity. An earth connection had formed in the negative conductor of a double line, the latter being composed of two parallel and identical protected cables laid in the clay. The following diagram indicates the way in which the defect was localised:—An ampèremeter is attached to each conductor where the line commences, and both conductors are united together to a powerful battery of accumulators. At the end of the line the conductors are looped together. The battery being connected to the earth at its other extremity the current is closed by the defect and by the conductors forming the shunts, M *b* N, and M *a* N. Measures have been taken for obtaining an intensity of current that will render the reading of the ampèremeter an easy matter. The readings, *a* and *b*, are inversely proportional to the resistances of the circuits in which the instruments have been inserted, and, as the conductor cables are identical, the resistances are directly proportional to the lengths in metres. It is as well to take into account any resistances from accessory loose cables in effecting the junctions with the ampèremeter and the battery.



Let x represent the length in metres from the commencement of the cable to the defect (shunt M a N); L the length in metres of the two cables (this length having been previously ascertained), and a and b the number of the ampères indicated by the instruments, the ordinary calculation of the ramified circuits is:—

$$x = \frac{b\,\mathrm{L}}{a + b}$$

In applying this method to the total length of a 900 metres line, an approximation was obtained of close upon 5 metres, the difference being attributable to difficulty in reading from ampèremeters of the ordinary type.

COMMUNICATIONS FROM AUSTRIA-HUNGARY.

[FROM A CORRESPONDENT.]

THE Buda-Pest electric town tramline makes constantly so satisfactory advances, that it already appears necessary to enlarge the central current installation of this line. On behalf of the undertaking of the town line which is applying for the concession of the execution of this extension, its necessity is urged along with the establishment of a new line, on account of the increased traffic on the most important lines. The concession will, without doubt, be granted.

At the Innsbruck electric central station, an interesting case has occurred. A spider was climbing, during the work, on one of the lightning protectors, and occasioned an earth connection, in consequence of which an induction bobbin was damaged by breaking the insulation. In order to prevent similar occurrences for the future, the lightning protector plates are closed up in glass boxes. The spider itself has paid with its life for its unwarranted intrusion into the primary circuit of 2,000 volts.

The Vienna Electric Company (not to be confounded with the International Electric Company, also established in Vienna), has erected in the Neubad Gasse an electric central station, with the use of the five-lead system. For employing this system in one of the most densely-populated quarters of the city, the company had to erect electrical works which naturally occasioned serious annoyance to the inhabitants, and, in consequence, an endless succession of law suits. The peculiar situation in which the company is now placed is illustrated by the following notice from the Vienna *Extra-blatt*. Says this paper: At last the thoroughfare through the Neubadgasse into the Naglergasse, after being closed for three years, is reopened. Still the process between the inhabitants and the electric company is not yet decided. The inhabitants, especially Prince Esterhazy (represented by Dr. Lichtenstern), Herr Wieser, of the Neubad Hotel, and Herr Haag, of the Hotel Müller (represented by Dr. Peiez), and the Knight von Weissenfeld (represented by Dr. Ziegler) have entered actions against the company, as the powerful machinery disturbs the quietness and causes the walls to vibrate. The company has been ordered to construct the machinery so as to abate the nuisance. But it has latterly appealed against this decision, and there is now a perfect complication of appeals, protests, decrees, and decisions. One night a 400 horse-power engine at the central station was set in action, when confusion at once arose in the adjoining houses, the walls trembled, the windows rattled, and Prince Esterhazy leaped out of bed in dismay. Count Kielmansegg the "Statthalter," a municipal official of higher rank than a mayor, at once visited the Prince's palace and the hotels Müller and Neubad, and convinced himself of the reality and the nature of the disturbance.

THE SEVILLE CENTRAL STATION.

A CENTRAL electric light station has been erected in the Calla de Las Mozas, Seville, and is described in a newspaper published in that town. The boilers comprise six of the well-known Belleville type, and four vertical compound Offman steam engines. Four compound dynamos of the Brown type are installed, each having an output of 480 ampères, at a difference of potential of 110 volts. These dynamos and the engines were made by the well-known Oerlikon Engineering Works, near Zürich, whilst the regulating apparatus was furnished by Messrs. Woodhouse and Rawson United.

The distribution of current is effected by means of mains laid underground. These mains consist of copper wires insulated by vulcanised rubber, and then encircled with leaden tubes, and laid in iron pipes, which form the conduit. Current is obtainable both day and night. The incandescent lamps employed range from 10 to 1,000 candle-power, and the arc lamps from 500 to 1,000 C.P. The price charged for current compares very favourably with that of gas, even when the cost of wiring is considered. Already a number of subscribers has been obtained, and, notwithstanding the local opposition, it is expected that the station will become a commercial success, and probably be the forerunner of several others in Andalusia.

CONFERENCE OF POSTAL TELEGRAPH CLERKS.

A SPECIAL conference of postal telegraph clerks will be held in Liverpool to-morrow, when the features of the recent revision of their status will form the chief subject of discussion. The importance of such a meeting can scarcely be exaggerated when it is remembered that the delegates attending represent the whole of the members of the postal telegraph staff throughout the United Kingdom, this section of the public service alone numbering, we believe, upwards of 10,000 members.

That the deliberations of this assembly will be followed with peculiar interest and concern by all parties throughout what is termed "the service" goes without saying, and to many who are not telegraph clerks, but who trace the course of current events, the reintroduction of that outcome of the "benevolent disposition" of the Postmaster-General and his administrators, "the official reporter" will revive the recently-discussed topic of the right to "free public meeting."

Many of our readers will remember the restrictions placed this year on all sections of Post-office *employés* holding such meetings, their general and almost unqualified condemnation by the press, and their plausible interpretation by the Postmaster-General in the House of Commons and elsewhere. General doubt was expressed as to the genuineness of the "benevolence" attending such unnecessary limitations, and it is melancholy news indeed to hear that the movement which the telegraph clerks have carried on so moderately and constitutionally has not been signalised by equal forbearance and consideration on the part of those for whom the Postmaster-General has professed almost too much in the House of Commons. We refer now to the dismissal of a well-known and popular member of the London staff; a young man whose only faults appear to have been his manly candour and his unswerving honesty of purpose.

Elected by the staff of the Central Telegraph Department to a position on the executive committee, intelligent, enthusiastic, and, as we have already said, honest, he in some way fell foul of the higher authorities, his dismissal being due to "what he had said," though where and when the negative or positive oration which led to this result was delivered was not vouchsafed.

It is gratifying, however, to learn that a promising opening has already been found for this young man, and that he has little to regret in leaving the Telegraph Department beyond the loss of seven or eight years of underpaid service. Possibly, if he be of a thoughtful or enquiring turn of mind, he may ask, in the words of Burns—

> Why was an independent wish
> E'er planted in my mind?

and, for an answer, the Postmaster-General might commend him to the same poet's lines on "The Creed of Poverty." Under the circumstances he will amply realise their point.

As might be expected, the delegates attending the conference will be asked to give utterance to an expression of sympathy with their late colleague.

It is no doubt one of the stock arguments of the Civil Service at such times, that examples must be made, and, that the line, as the hangman said, must be drawn somewhere, so we are not surprised to hear that others are under a certain degree of official displeasure. The effect of such incidents on the calm debating spirit and general character of a conference such as that under notice cannot be said to be reassuring, but we trust that in all its transactions the special conference of telegraph clerks will refrain from taking up a position which might be construed as expressive of resentment, defiance or disgust, at the same time exhibiting neither timidity nor panic, but holding steadfastly on for the recognition of those claims which are reasonable and justifiable in the general interests of all classes of postal telegraph clerks.

We have made a careful study of the new scales of pay, their methods of application, new system of sick pay, hours of duty, the matter of annual leave, and last, but not least, the vexed question of a "reasonable prospect." These important points it is our intention to discuss more fully hereafter. We find that much as has been done by the Postmaster-General and those who have been at his right hand throughout the framing of the new scheme, there still remains much to level up and much to clear away.

The substantial benefits conferred must not be lost sight of by the conference, neither should they be overrated, as some of the reforms may be said to be more apparent than real, and it will not be until July, 1891, that the general body of telegraph clerks will feel any appreciable improvement in their salaries.

It will not inspire the public with very high ideas of the way things are being administered in the telegraph service when it is known that increments were given under the new scheme at some of the provincial offices recently, and recalled in a week or two after. This may be a playful method of perpetrating a joke, but there is something very clumsy about it notwithstanding, and no one will envy the feelings of the unfortunate individuals concerned.

Whether revision of the new scales of pay may be practicable at the present time or not we cannot say, but it is stated that they are not regarded as being entirely satisfactory, and we believe that moderate and rational methods will gain for the telegraph clerks the more equitable settlement of such minor points as appear to us to require improving. For instance, the inconsiderate system of stopping the pay of the poorer sections during absence through sickness, whilst others have gained the great boon of exemption from deduction or stoppage, will, we think, if properly represented, be remedied. The question of annual leave will also bear remodelling, and we are hopeful that the Postmaster-General has not yet exhausted his beneficial resources; and no doubt the conference will recognise other features on which they may feel it their duty as well as their privilege to approach the Postmaster-General.

CORRESPONDENCE.

Alternating Current Meters.

Referring to the letter of Mr. Tesla in last week's ELECTRICAL REVIEW on the subject of alternating motors, I should feel obliged if you would allow me to modify some statements therein contained with reference to an alternating current meter devised by Messrs. Alderton, Philpott, and myself, and recently perfected by Mr. Ferranti.

In August, 1888, while experimenting with an alternating current meter made on the principle suggested by Prof. Ferraris in the spring of that year, viz., surrounding a copper cylinder, capable of rotating, by two coils at right angles to each other, through which two currents differing in phase were passed, the difference of phase being obtained by using the currents from the primary and secondary of an induction coil. I modified this arrangement by substituting Mr. Tesla's ring-shaped field with two pairs of coils wound on the quadrants, and passed through these two circuits respectively, currents from the primary and secondary of a transformer, instead of using a special two-phase generator, as employed by Mr. Tesla. Then a co-worker of mine in the same field, Mr. G. Alderton, suggested making the above ring-field act as the transformer itself by short-circuiting on themselves a few turns of copper wire in two opposite quadrants and sending an alternating current through the other quadrant's coils. This answered, but was greatly improved by making each of the two short-circuited secondaries only cover an octant instead of a quadrant, and the first meter of this form was put in the Grand Hotel at Brighton in September, 1888.

Mr. G. J. Philpott then discovered that rotation of the iron disc could be produced by placing it in the field formed of laminated iron stampings of the shape of a J, the disc being put near the curved part of the iron, and the straight part magnetised by an alternating field. We then found that the rotation was very much accelerated by putting a few short circuited turns of copper wire round part of the iron magnet which was uncovered by the exciting coil. Within a week of this improvement being made, we were naturally disappointed to find in the ELECTRICAL REVIEW that Prof. Elihu Thompson had forestalled us in some of our forms, and in enunciating the most probable cause of these rotations, namely, the gradual movement of the magnetic poles along a mass of iron in or around which secondary currents are allowed to be generated, or as Dr. Fleming happily puts it, "a gradual shifting of a magnetic pole takes place owing to the *high magnetic self-induction* of the core." I may add that Mr. Philpott found that these rotations could be observed in certain positions near a loaded transformer in which the magnetic leakage was excessive, and thus formed a rough test of the transformer's defect in this respect.

I quite think with Mr. Tesla that his latest method of obtaining rotations by magnetically screening part of the iron poles is distinct from the method mentioned above, but think he is wrong in stating that the rotation in our meter is due to the same cause as that in the Schallenberg form. There appears to be several methods of producing this valuable effect of rotation of an armature without collectors or commutators, in an alternating field, which do not necessarily all require the same explanation. For instance, I would refer your readers to the interesting electrical apparatus devised by M. Fontevielle and described in the ELECTRICAL REVIEW in July 1880; also to the wonderfully ingenious meters devised by M. Borel and Paccaud in 1887 and patented in this country in January, 1888. Perhaps the above may show Mr. Tesla that it is quite possible for different individuals to work in this interesting field, without the fact of like results being obtained, in any way detracting from the individual merits of their labours, or that there can be only one cause for these rotations.

Arthur Wright.

October 7th, 1890.

Telephone Induction Coils.

In your last number you have a description under this heading of an arrangement by Mr. T. D. Lockwood in which a closed magnetic circuit induction coil is used in conjunction with an ordinary open ended coil. It is not, however, of this that I wish so particularly to speak as of the editorial note appended, in which you state that you "witnessed some experiments a few years ago with coils constructed like transformers, to be used for translation purposes from a single wire to a double wire system, but the speaking results were extremely poor, though the ringing of the call bells (in the magnets principally), was all that could be desired. On the other hand it was found that when ordinary induction coils were used as translators the speaking was excellent, but the magneto bells would not ring."

Now in connection with a patent taken out in 1885 by Mr. Ferranti and myself we carried on an extended series of experiments with coils of this character, particularly with a view to their use as you describe, viz., as translators from a single to a double wire or *vice versa*, and with the intention that the call signals should be made right through both coils by induction without the intervention of any extraneous apparatus. Several curious and interesting effects were obtained exactly in accordance with theory, in fact such coils can be made to illustrate many of the laws of induction in a most pleasing and convincing manner.

The results vary in accordance with the way the coils are constructed, but it is by no means the case that when the coils are properly made the speaking results are extremely poor. In some experiments at the telegraph office on an underground wire to Gloucester Road, for which facilities were kindly afforded by Mr. Preece, the speaking through the coils best suited to the work was found to be indistinguishable from that through coils which the Post Office authorities, after many experiments, had found to give the best effects. In addition to this of course the closed circuit coils possessed the advantage that call signals could be transmitted through them, even when the resistance of the circuits was considerable.

It is true that coils can be constructed to give astonishing results when signalled through, but in which the speaking is poor, if the main line has any appreciable capacity, such a form, however, must be avoided.

I send you this note in the interest of closed circuit coils when used as translators. When used as transmitter coils they certainly do not appear to be successful, no doubt for the reason advanced by Mr. Lockwood.

The whole subject, however, demands fuller and more exact treatment than it has yet received.

G. L. Addenbrooke.

October 1st, 1890.

Electrical Heterodoxy.

It can be easily seen there was no attempt to disguise the logomachy of my letter, the whole subject has been a contention of words ever since Benjamin Franklin enunciated the one force theory of electricity, in which positive and negative (now + and −) *mean* plus and minus.

But why does Mr. Johnstone take me to task over the one particular paragraph, there is not a great deal of logomachy in contending that plus and minus electrification and the quality of polarity do not necessarily force one to believe in two electricities. If plus and minus anything are not opposite and therefore polar qualities, I fail to understand what + and − mean. Had I written positive and negative electricity Mr. Johnstone's objection might be valid. I am not so sure the other paragraph would have remained unwritten had I perused Mr. Johnstone's book, it would take a lot of evidence to prove to my satisfaction that glass is porous in the sense referred to. Mr. Johnstone writes of electric matter passing through the pores of glass. What is this "electric matter"? A substance of course, or it could not be matter and what are these "particles of a current of electricity." In contending for his "electric matter" Mr. Johnstone must beware of getting logomachic, for there was a theory of an electric fluid, and I suppose fluid must be matter. I presume the test tube used by Mr. Johnstone, also the several referred to in the editorial article were (according to Mr. Johnstone) sufficiently porous to let the "electric matter" through. Notwithstanding Mr. Johnstone's theory that a Leyden jar becomes charged because of the smallness of the glass pores and therefore the above series of test tubes most unsuitable material, I fancy few experimentalists will hesitate to say the whole lot of these non-perforated porous tubes would make very fair Leyden jars.

Really there is little necessity for me to read Mr. Johnstone's book.

It would have been more to the point had Mr. Johnstone shown the apparatus illustrated in my letter *did not* tend to prove the explanation in the editorial article and also to have shown that my surmise, *re* the gas flame was incorrect.

But why this contention for electric matter, fluid or what not? When things might be simplified by the endeavour to demonstrate that electrical effects are the results of certain conditions of motion in the matter of the circuit itself, whether the effects or circuits be electric or magnetic, I have not brain power sufficient to say how and why but feel sure a future Faraday will arise and put us right in simple and truthful language.

As this logomachic correspondence can do little else than waste valuable space, it is concluded so far as I am concerned.

Henry Sutton

October 4th, 1890.

Fusible Cut-Outs in Armatures.

Your correspondent "E. J. M." will find his enquiry of 5th ultimo answered by referring to United States patent, No. 281,904 of July 24th, 1883, wherein I have covered the use of fusible plugs between each section of the armature and the corresponding segments of the commutator of both dynamos and motors.

J. M. McMahan.

October 2nd, 1890.

Reciprocating and Stationary Lines of Force.

Prof. Elihu Thomson, in his recent communication to you in your issue of September 26th, appears doubtful as to whether the lines of magnetism emanating from the axial solenoid in his new machine rotate with the revolving core and armature; and we are told "the actions would be the same whether they rotate or not." This, I think, is a somewhat hasty conclusion, even from such an authority; for if the classification of physical or magnetic actions is permissable, and, as experience teaches, desirable, then the distinction between fixed magnetism and reciprocating or vibrating magnetism would determine the category in which this machine should be placed: if in the induction coil class or with the Gramme or Siemens type of continuous current machines.

The former depend for their current on reciprocating lines of force intersecting an electrical conductor, while the latter produce current by the continuous movement of a conductor through fixed lines of force.

It is as well to be clear, to lay hold of the right line of thought, to see the path we are treading and whither it may lead, even though ultimate results may at present be obscured by the mists of uncertainty. It is reassuring to feel that one is on the right track.

Like a man, a dynamo has an inside and an outside. The latter may not be impressive or picturesque; but it is the inner life, the lively and conflicting forces to be seen only by the mind's eye, that makes electrical contrivances so interesting.

Logically, it would appear desirable to call all machines induction coils or transformers that depend on the reversal, variation, or cessation of magnetic force; whether these changes be brought about by an automatic contact breaker or by the mechanical rotation of masses of iron under inductive influence; the necessary periodicity of change in magnetic state being produced either electrically, by the make and break apparatus; or mechanically, by the rotation of an iron armature of a suitable shape, so as to cause a rhythmical and variable magnetic action.

It is feasible that the *result* would be the same—that is, more or less—whether the magnetism revolved or not in Prof. Thomson's alternator. But a result may be the consequence of many actions, and it is a legitimate field for enquiry to find out what these actions are.

There would seem to be much opposed or conflicting magnetism in this alternator—possibly a detail question in construction. For instance, the bobbins on the periphery of the machine are double in number to the projections of the armature; and by the continuity of the magnetic circuit, which obtains its energy from the axial solenoid, all the bobbins are in themselves more or less saturated, and all of like polarity, without reference to the armature. But as the armature can only cover half the number of bobbins, it follows that a polarity of opposite sign must necessarily be induced in every alternate bobbin not covered by the armature, and this sign would be opposed to that which it would acquire from the framework of the machine, while its direction would be at right angles to it. There are some conflicting forces here.

With reference to the distribution of the lines of magnetism in the core or axis, and in the armature itself, if the armature were a drum instead of being variable in mass, I am certain it would rotate through the magnetism the same as the core of a Gramme armature passes through the magnetism held in space by the inductive action of its field magnets. The fact of the armature being irregular in shape, or heterogeneous in mass—having regard to the space it occupies in revolving—is why I have a little doubt about its action.

It is the excitation of the solenoid that brings the magnetism into existence, and that is a fixed element. If the cause is stationary, should not the effect be stationary also? I cannot conceive magnetism to be elastic; if it were so, dynamo machines would have been an unknown commodity and an impossibility. I have written on this part of the question before in the columns of your contemporary, the *Electrician*, 1887.

Enclosed is an illustration or suggestion for an experiment which would decide the point. I have no opportunity for making it myself. On the shaft (fig. 1), each side of the armature, is a metallic band, insulated from but fixed to the shaft. A number of copper strips are in electrical communication with the bands, and go over and enclose the armature as shown, preferably placed at about the centre of each cavity of the armature. Collectors on each side. The central and exciting coil and the frame are shown in section, while the armature with the conducting strips is in perspective.

Now, if the magnetism rotates with the armature, there should be no decisive indication of current through the collectors, because if the magnetism rotated at all, it would travel at the same speed as the armature and the conducting strips. But if the magnetic lines are stationary, then there should be unmistakable evidence of current; in fact, it would be a continuous current dynamo of its kind.

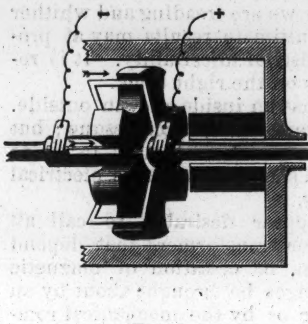


FIG. 1.

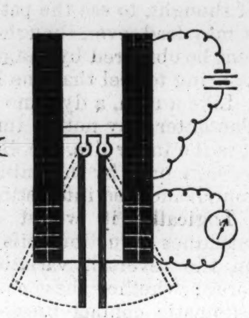


FIG. 2.

However, the immediate or direct cause of current in Prof. Thomson's machine may be explained on the reciprocating or vibrating principle. Let fig. 2 represent the section of a compound solenoid having a primary and secondary coil, the secondary being wound on the end. It is not difficult to make an iron model of a line of force, greatly magnified, no doubt; and for convenience of illustration some are hinged and suspended at the inner side near the equatorial part of the solenoid. Let the primary coil be excited, and these iron lines of force will repel each other, and strive to cut their way through the coil in order to assume the position shown by the dotted lines. In doing so they will have intersected the wire of the secondary coil, and have generated the inverse current. Break the primary circuit, and the magnetic lines cut the coil again, by falling back into their first position, generating the direct current.

When the magnetic lines remain in their extended position, by reason of the primary current, the rapid rotation of an irregular mass of iron near the end of the magnet would cause the lines of force to vibrate through the secondary coil and generate alternate currents similarly to an induction coil.

E. L. Voice.

39, Gower Place, W.C,
October 6th, 1890.

The Elmore Copper Companies.

Assuming the Elmore process to be a success there is as much justification for a company to work it in every country which uses the metal as there is for an English company, and the probability is that one would be formed for Timbuctoo if occasion warranted. But the laws of political economy cannot, unlike, therefore, the copper industry, be revolutionised, and supply will always be subservient to demand, and Timbuctoo will be without its Elmore company.

It having been proved that the process is a success and valuable, no criticism will be logical which condemns the Austrian and French Companies without condemning at the same time every other Elmore company. To prove the value of the process two things have to be shown; firstly, that the tubes which are admitted to be produced, have intrinsic merit and consequently marketable value, and, secondly, that the cost of manufacture is commensurate with the price the product will obtain on the market. This is the nut-shell of the whole case, and whatever the results may be the connection of Messrs. Woodhouse and Rawson with the process neither makes it better nor worse.

An enquiry on the above two points would have elicited such information as I will give you, and with these facts before you, instead of condemning without enquiry an invention you should encourage, your six columns might have been devoted to better purpose. Now, as regards the first point; every expert who has tested the tubes has satisfied himself that they are much stronger than those made in the ordinary way, and, as a matter of fact, the company guarantees that every tube it supplies shall have a tensile strength far above that of any tube of similar dimensions.

As to the second point, namely, the cost of production, the company is now, and has been for some time, working at an actual cost of $\frac{1}{2}$d. per lb. of deposit, and this statement has been confirmed by Dr. Hopkinson, who visited the works last week. This is, by the by, very much less than Mr. Elmore's original estimate, which, I think, came to over 1d. per lb. Now, I have shown on evidence which cannot be fairly disputed, that the company produces a superior article at a ridiculously low price; and the sole remaining point remains, Is there a market for the company's commodities? Given a better article at a lower price, common sense will tell one what the result will be.

The statement of Mr. Clark to which you refer in your article, has no bearing on the case, for the simple reason that he was alluding to ordinary electro-deposited copper, which for utility cannot be compared with Elmore copper; while as to the extract from Mr. Parker's report, with its obvious error in the proportion of the decrease of tenacity, no stronger evidence can be given of this gentleman's opinion than the fact that he has become a shareholder in the company since the date of his report.

Good wine, notwithstanding the old maxim to the contrary, does need "bush," and before anything can be appreciated at its true value, time, labour, and advertisement must ensue. I thoroughly believe in the impending revolution in the copper industry, but I am, although a shareholder in the Elmore companies and therefore, according to you, a fool, not sufficiently foolish to think that it will be effected in a few months

A Shareholder.

The Sweating System.

Kindly allow me through the medium of your widely read journal, to call attention to the rapid strides that are being made in the electric lighting industry by that common enemy the sweater. Although our business is comparatively new, the sweater is there in all his glory, competing seriously with first class firms who pay fair wages which will cause them eventually to reduce theirs. It behoves both employers and employees, whose interests are inseparable, to make a determined stand against these men, and they cannot start too soon. Other trades, just lately, have had to fight this question out and undoubtedly we shall have to do so in the near future. It is not alone the small wages paid by these men, but it is the bad material that is put in, thus injuring our trade by the constant breakdowns that occur, and preventing intending users from adopting the light. The only remedy that I can see is by the first class firms combining and crushing the men off the market.

Being a member of the Electrical Trades Union, and knowing a great many, both union and non-union men, there is amongst them a genuine desire on their part to do something to eradicate this pernicious system, or we shall be obliged to work for little better than a starvation wage; and I am heartily ashamed to know that many of these sweaters originate from men of our own class. I should like to ask my fellow workmen what they are going to do? If they stand aloof they are against themselves and the men who desire to put a speedy end to this pernicious system. Hoping that the outcome of this letter will be to bring forward some practical suggestions from employers and employees,

An Electrical Trades Unionist.

October 7th, 1890.

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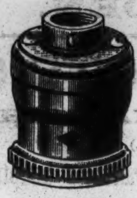

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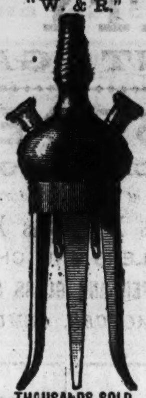

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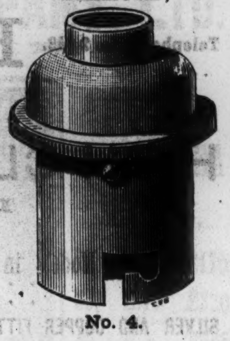

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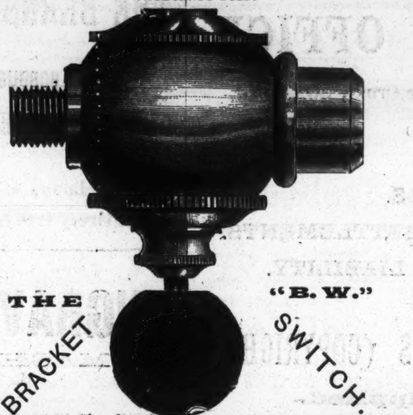

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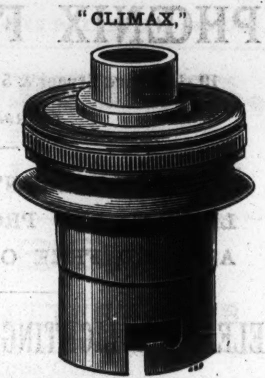

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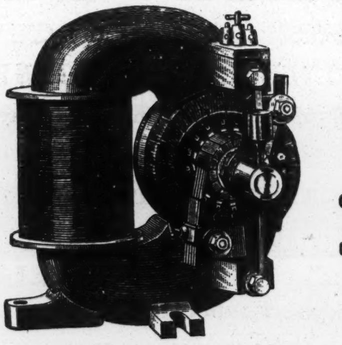

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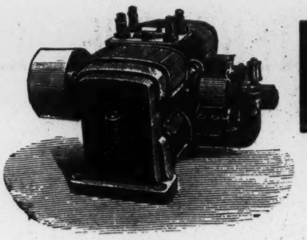

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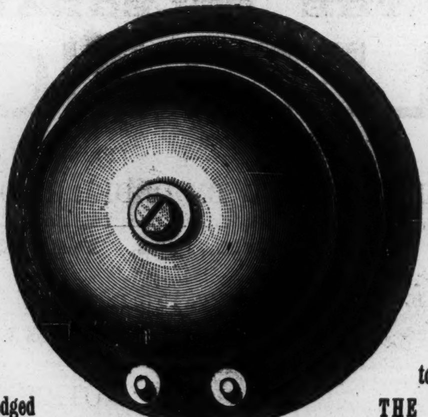

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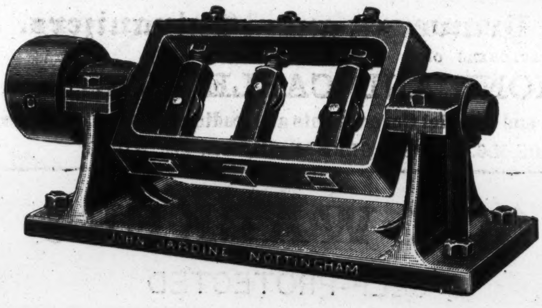

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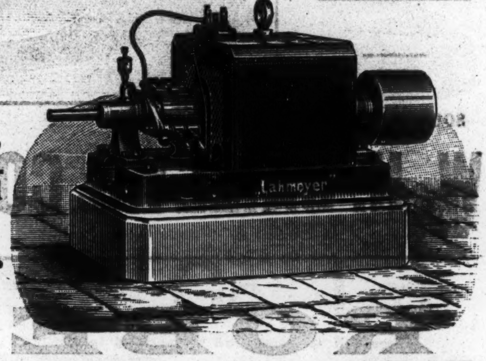

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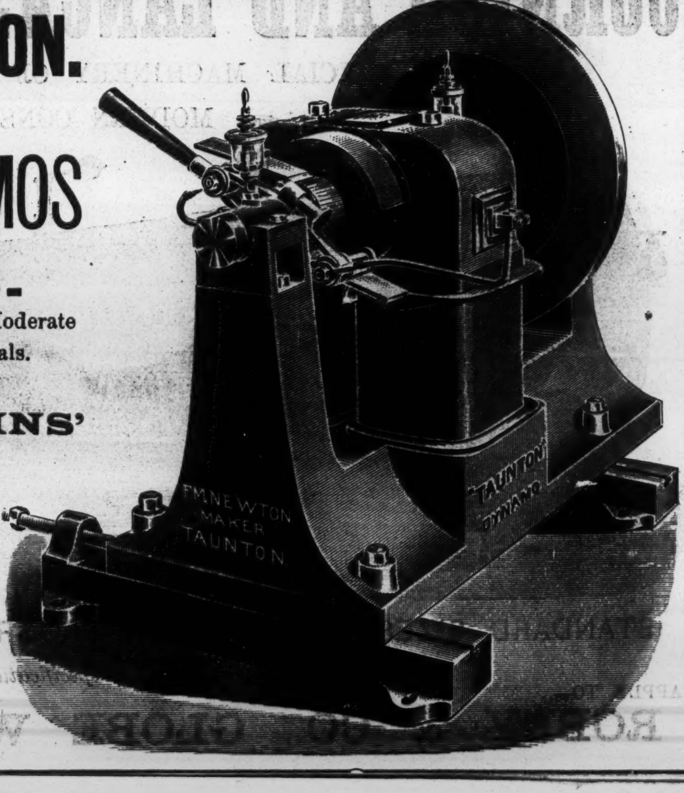

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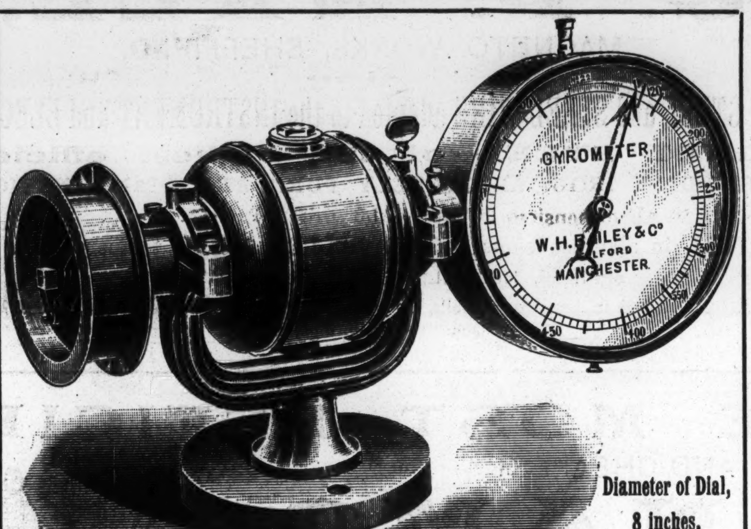

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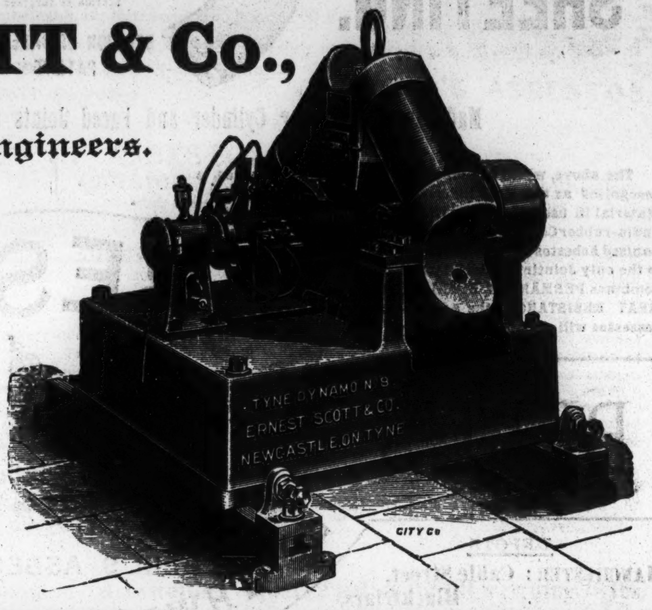

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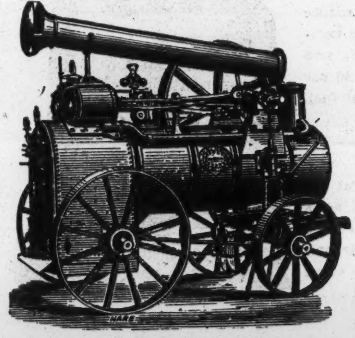

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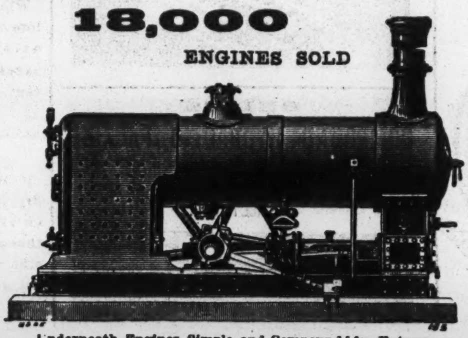

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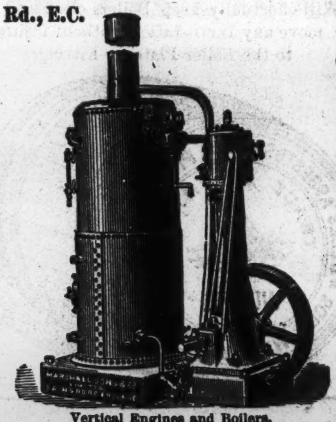

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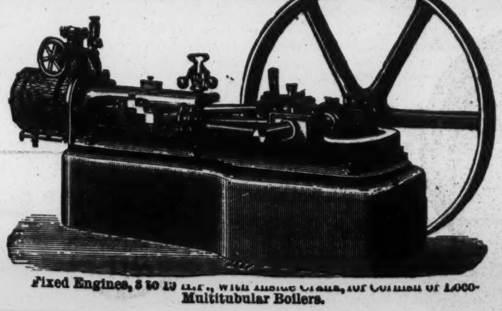

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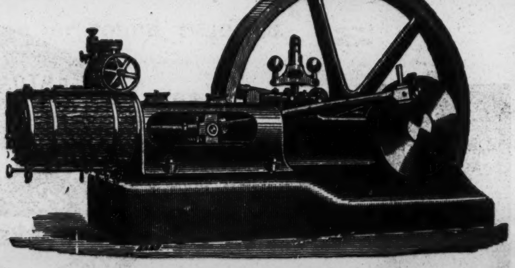

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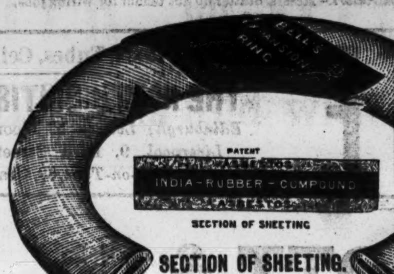

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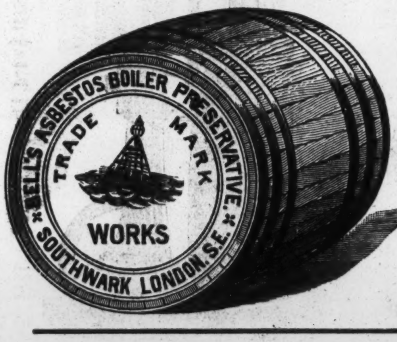
Will effectually keep Boilers clean and remove any Incrustation, without injury to the Boiler Plates or Fittings.



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Will reduce loss by radiation, and saves 40 per cent. of fuel.

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Is sent out dry in bags therefore cheaper than others sent out wet.

All bags are marked as above.

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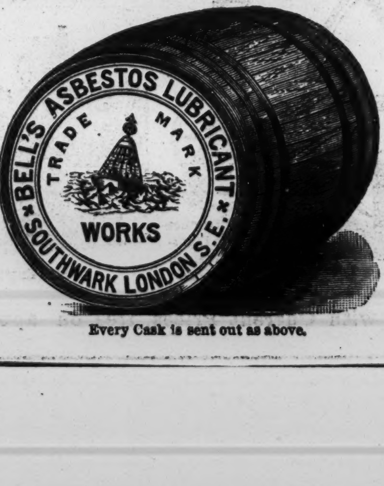
Any customer receiving Oil sold as Bell's Asbestos Lubricant, & Cask, Drum, or Corks not marked as shown, is earnestly requested to forward us sample and particulars of where obtained.



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Every Cask is sent out as above.

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BELL'S ASBESTOLINE.

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All kegs are labelled as above.

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ASBESTOLINE is the most efficient Lubricant for all bearings.
ASBESTOLINE is the cheapest Lubricant.
ASBESTOLINE saves from 50 to 90 per cent. of the Cost of Oil.
ASBESTOLINE is the Cleanest Lubricant.
ASBESTOLINE is favoured by Insurance Companies.
ASBESTOLINE is the most Inodorous Lubricant.
ASBESTOLINE is the safest Lubricant, its flashing point being 700 F.
ASBESTOLINE has beaten all other Lubricants in making trials.
ASBESTOLINE is applicable in and out doors in every climate.
ASBESTOLINE requires no special application.

TRADE MARK.

BELL'S ASBESTOS.

CONSISTENCY OF ASBESTOLINE.

ASBESTOLINE, to meet all circumstances, is made in four degrees of consistency, A, B, C, and CC.

ASBESTOLINE A, is specially adapted to ordinary Land Engines and Machinery, in and out-door, in this country.

ASBESTOLINE B, a little more solid, is for use on Steamships in temperate climates, also on land when it is desirable to have Lubricant stiffer than A.

ASBESTOLINE C, is for use in tropical climates, both ashore and afloat. It is also invaluable in works in this country when the temperature is high.

ASBESTOLINE CC, is designed for use on calenders, paper machines, &c., where the bearings are heated by steam passing through, and sometimes is advantageously used instead of C.

The reputation of Asbestoline as a lubricant of the highest efficiency in every kind of machinery is established, and it has never been equalled by any other lubricant in the numerous cases of special difficulty in which the best oils are ineffectual. This reputation is growing daily, because it is **based on the experience of thousands of users** under the severest circumstances any lubricant has ever been subjected to, **and not on mere laboratory tests** and professional analysis of insignificant quantities. It is used with marked success in Steel and Iron Works, Collieries, Cotton and Wool Mills, and other Textile Manufactories. In Corn Mills it has proved invaluable on the roller and other modern machines. In Saw Mills, on Machines going up to 5,000 revolutions per minute, its work has never been approached by any other lubricant. On Electric Lighting Machinery, and in Steamships of all sizes throughout the world, the success of Asbestoline is unequalled. Many engines and machines of all descriptions give trouble and show bad results, both in working and wear, when the system of lubrication has not received due consideration. Engineering firms of the highest standing have given to it their powerful testimony and support.

SUPPLIED IN KEGS, 28 lbs., 56 lbs., or 112 lbs.

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DAGGER PACKING.

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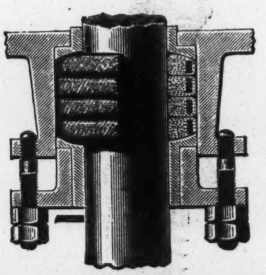

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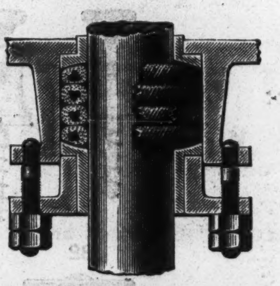

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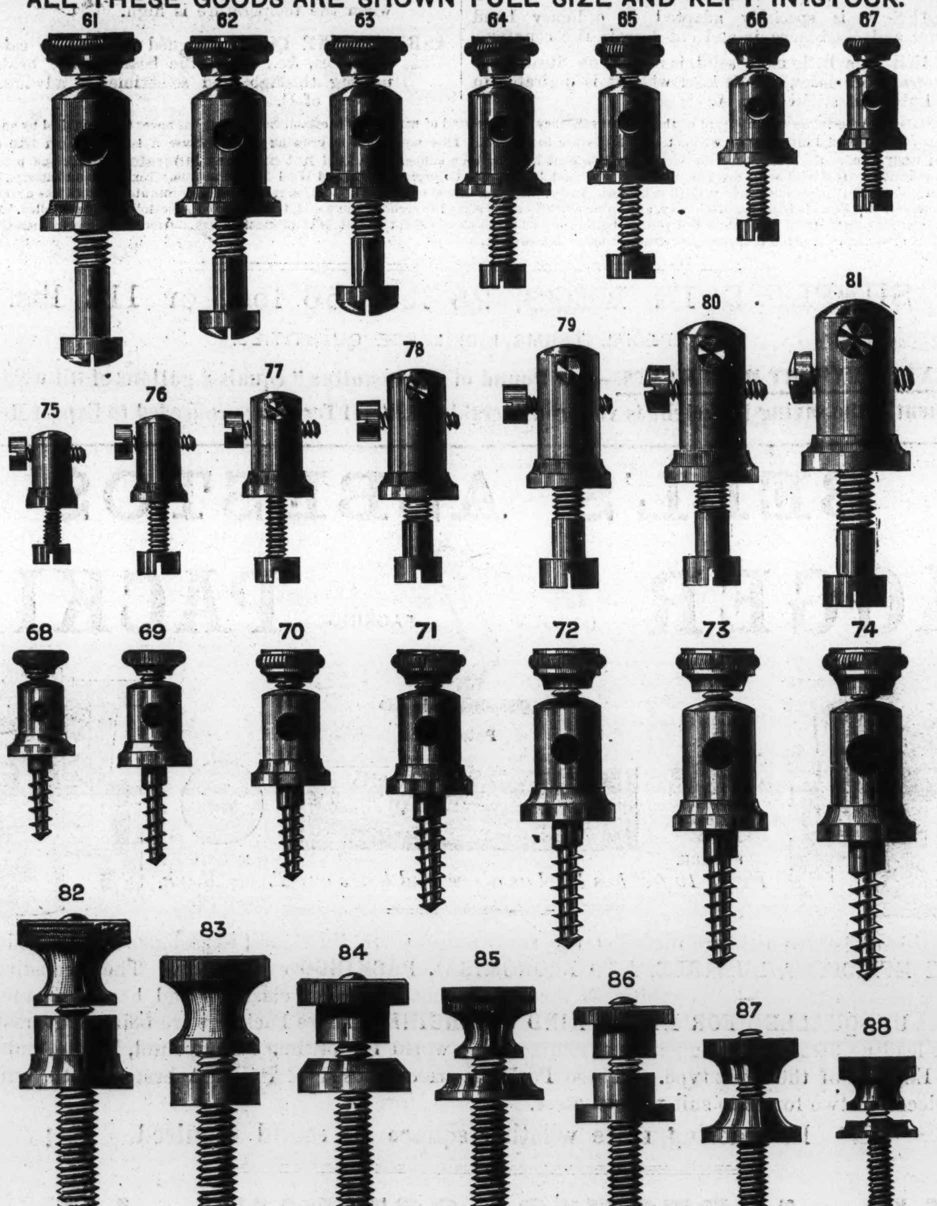

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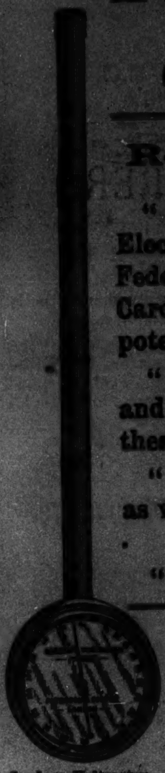

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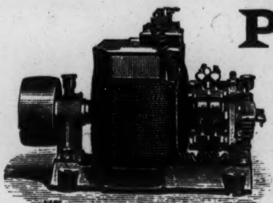

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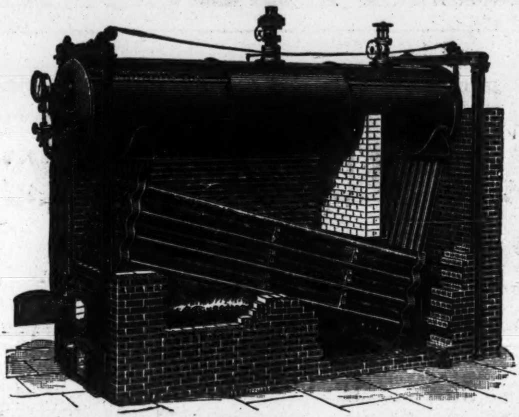

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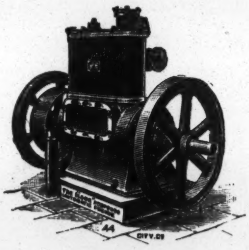

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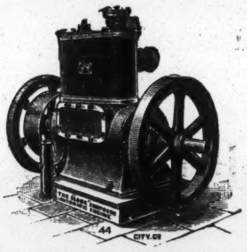

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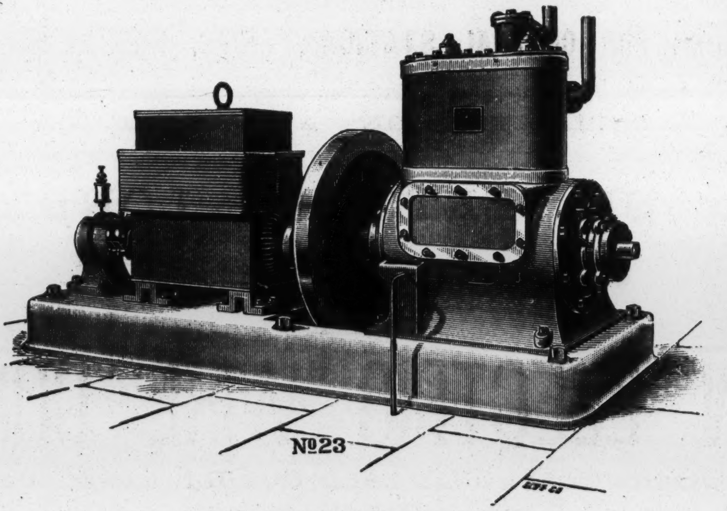

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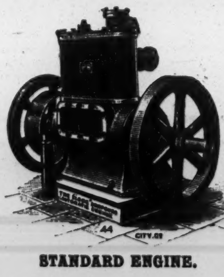

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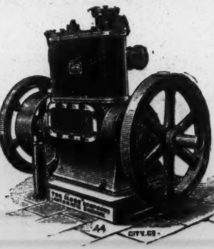

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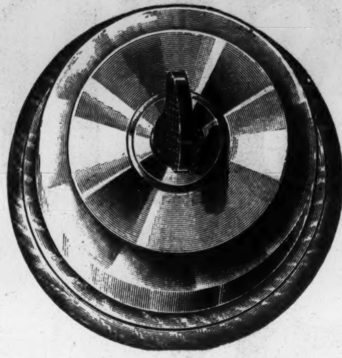

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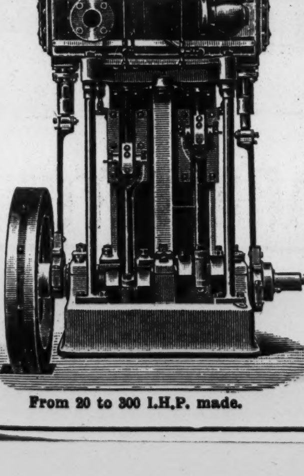

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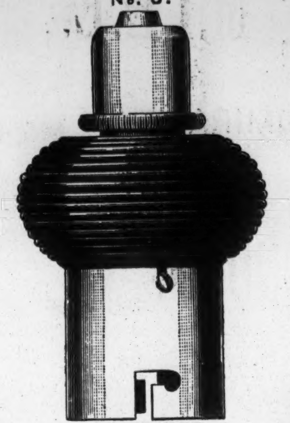

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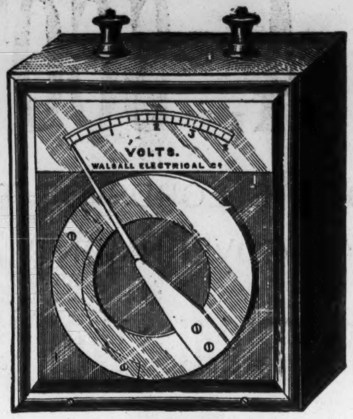

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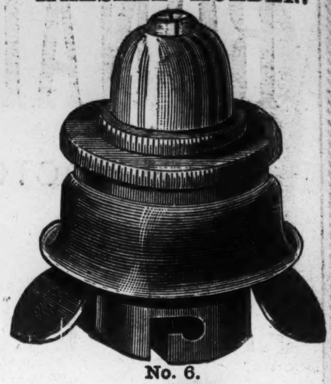

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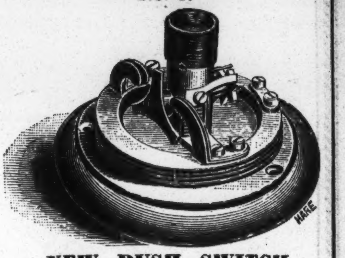

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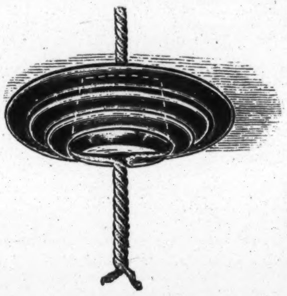

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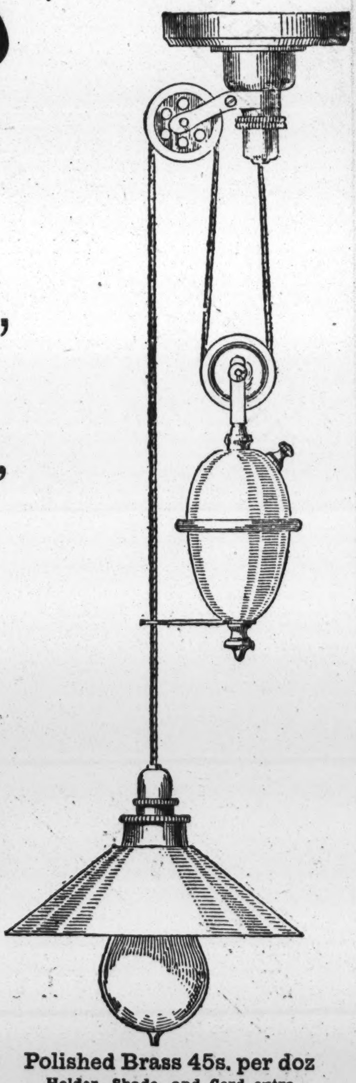

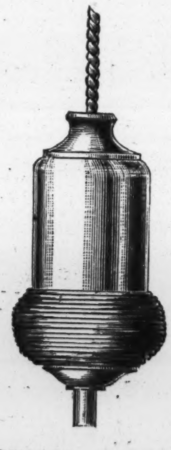

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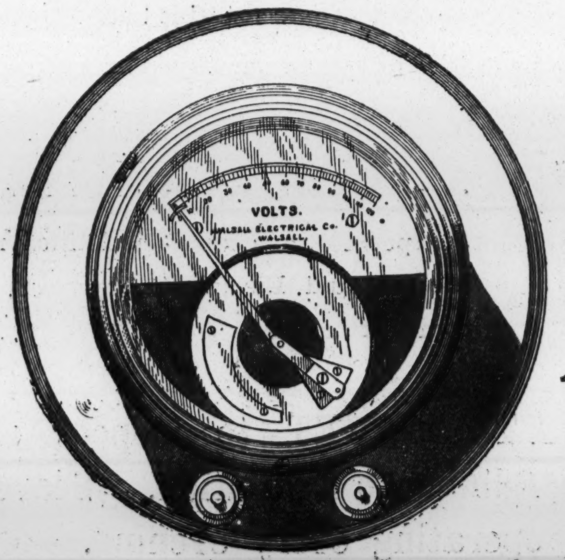

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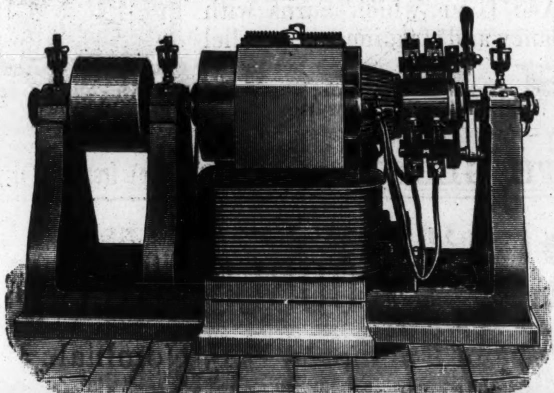

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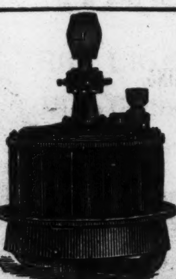

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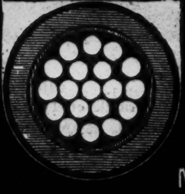

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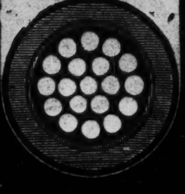

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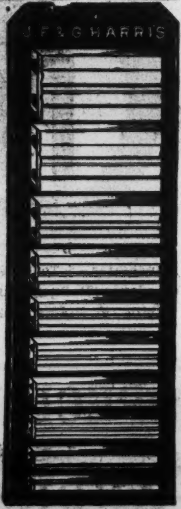

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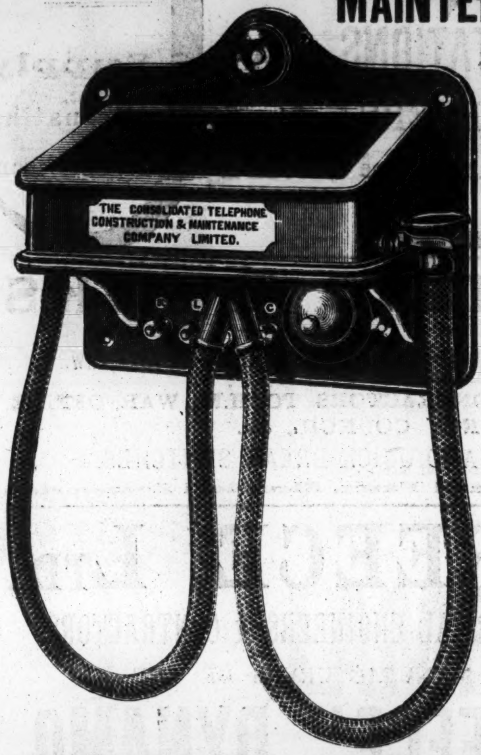
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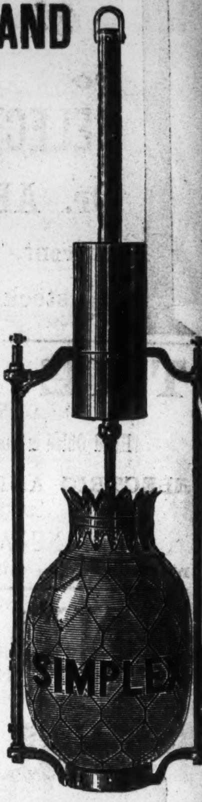

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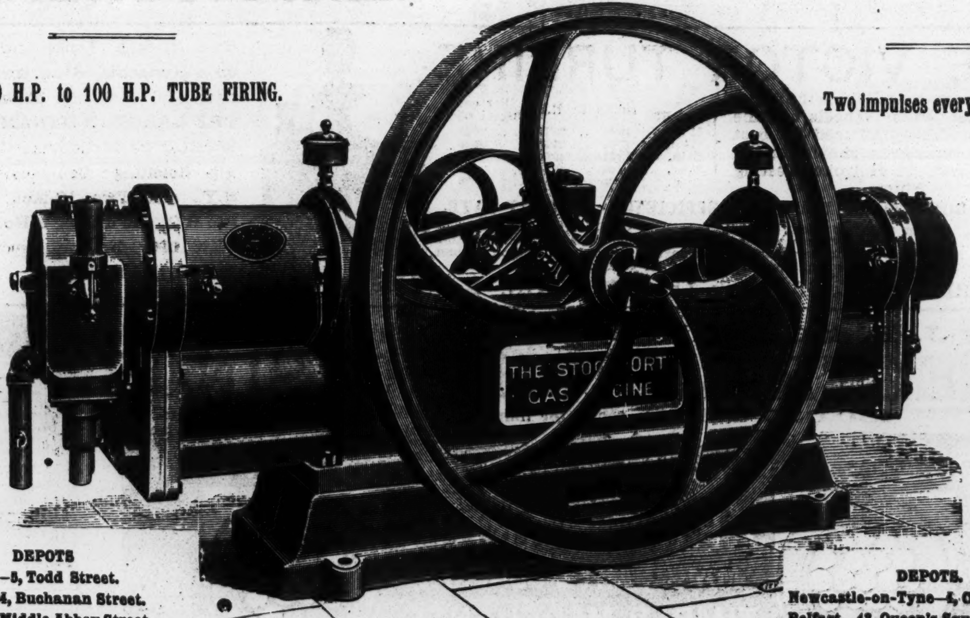

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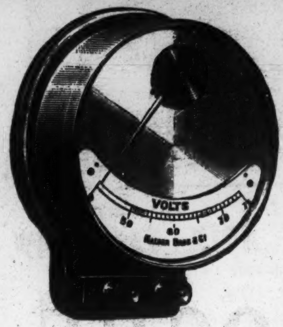

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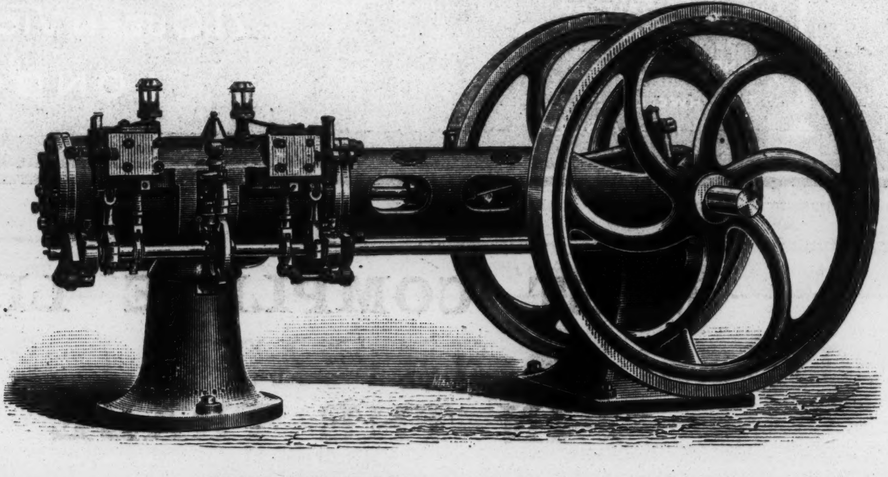

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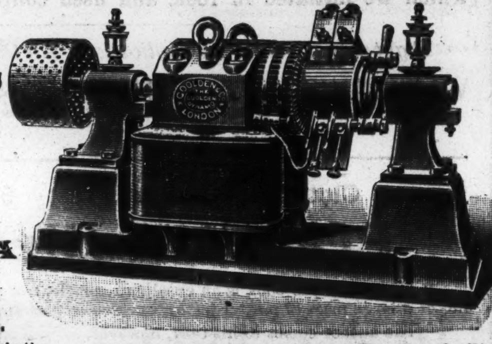

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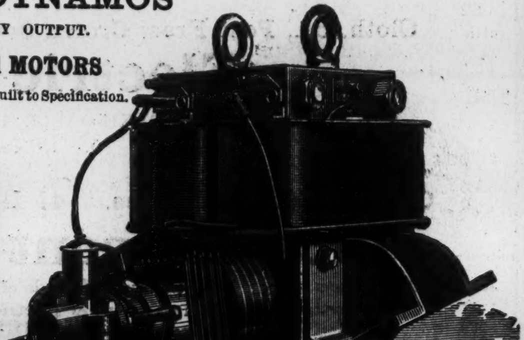

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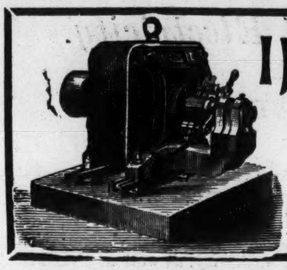

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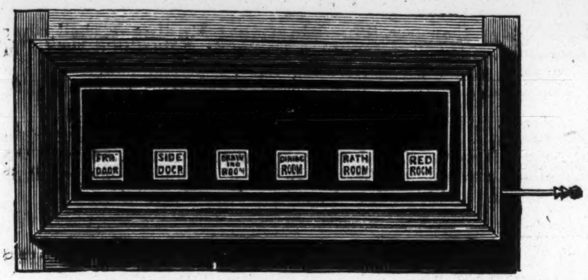

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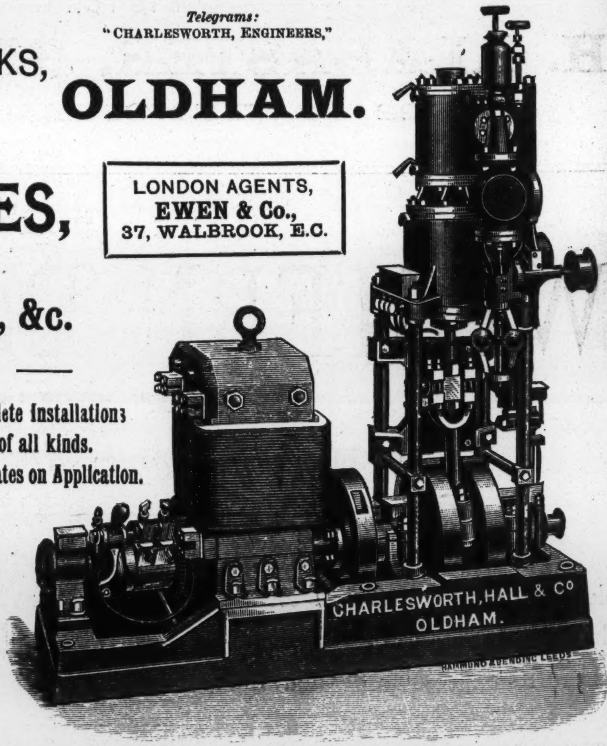

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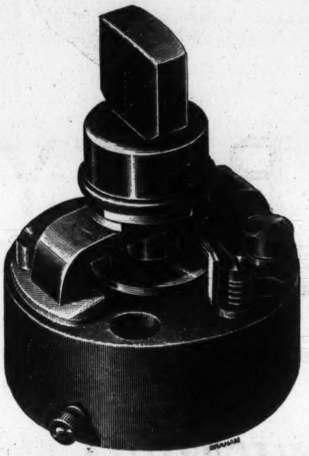

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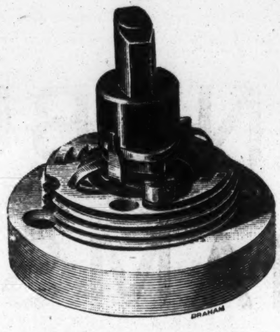

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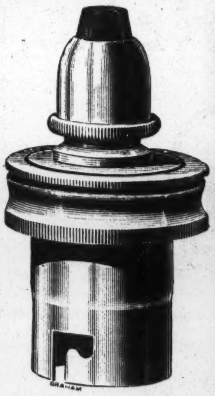

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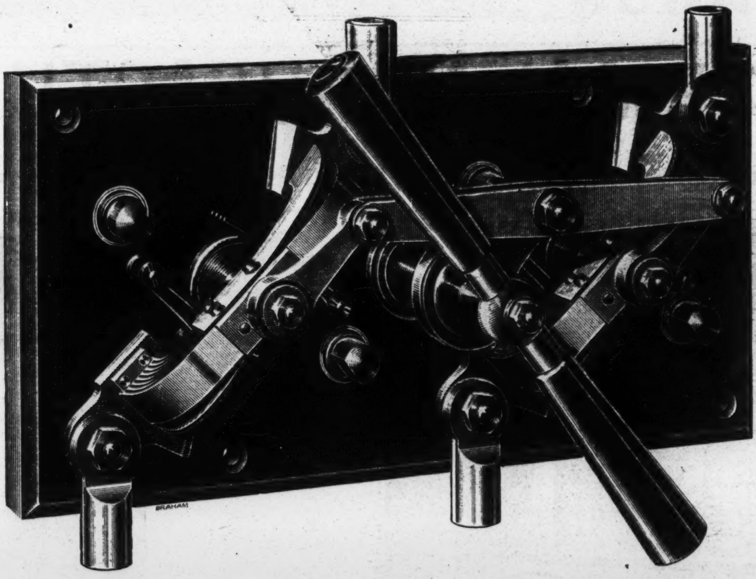

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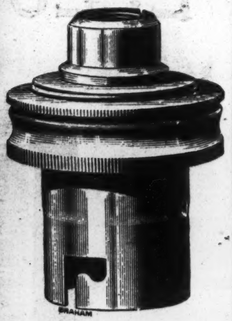

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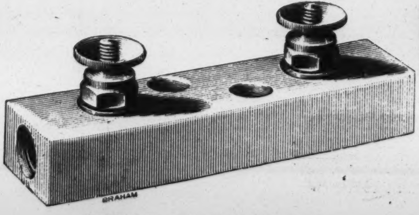

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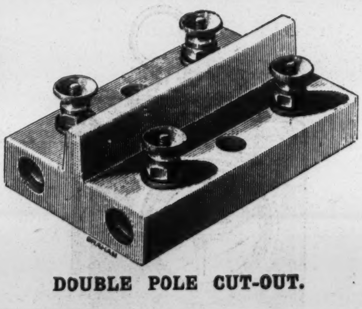

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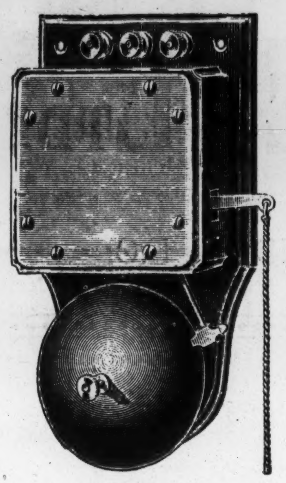

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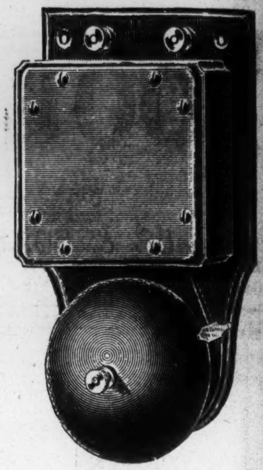

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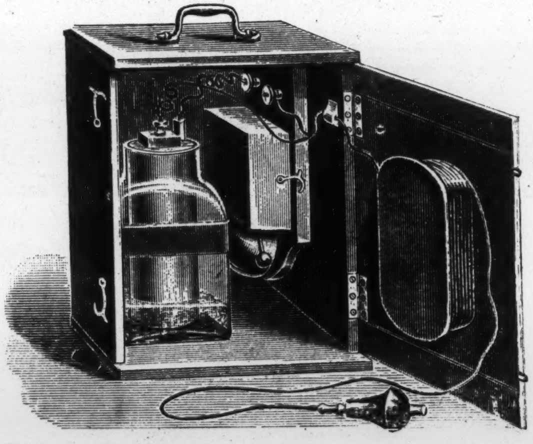

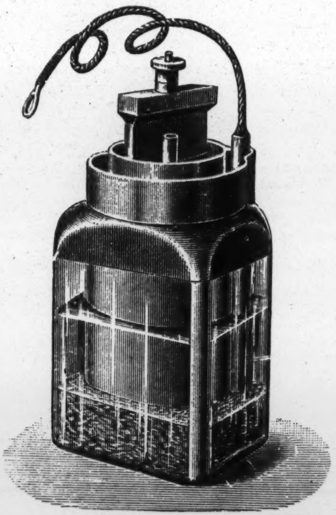

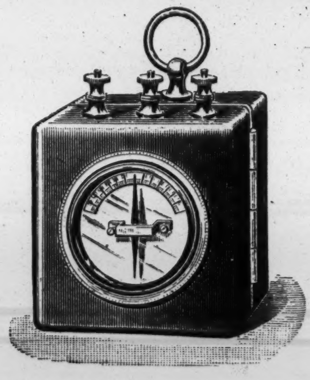

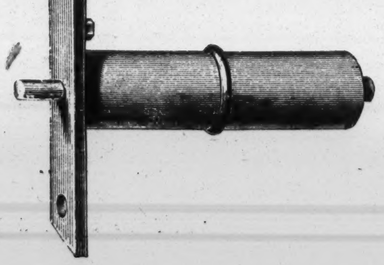

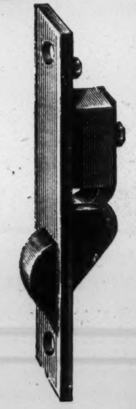

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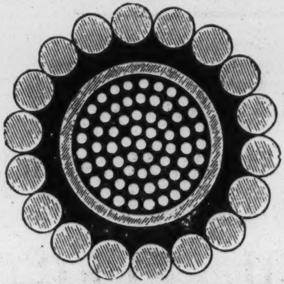

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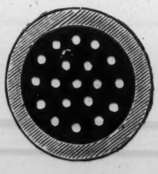

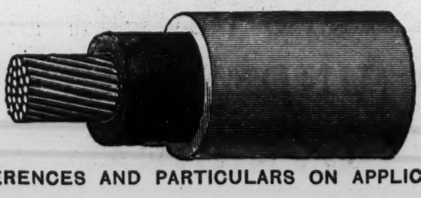

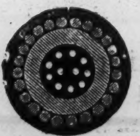

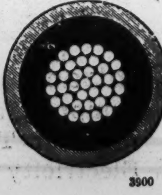

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